POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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THE AGE OF POWER

SYMBOLIZED in this striking view of the main material distribution tower at the Grand Coulee Dam project on the Columbia, is today's "Age of Power." Here, with the aid of modern machinery and "power" a comparatively few men move more material in a single day than could have been moved by ten times the number of men in a month, a generation ago. Today's age of power must be differentiated from the machine age of a generation ago—they are not the same as many people believe. The machine age dated back to the first part of the 19th century—to the invention of the steam engine. The power age on the other hand began with the development of electric transmission and distribution systems which extended the application of power enormously. Before electric transmission, power had to be used in the immediate vicinity of the point of generation. Electric transmission systems enable power to be used anywhere, regardless of where it is generated. This has done more to change the pattern of our civilization than any other single factor in historical times.

With the Editors

Why a Review?

A LOGICAL question considering the limited power plant construction during recent years and predictions, freely made not so long ago, that the industry having reached a plateau in the improvement curve would show little advance until some startling new development came along.

That development has arrived, but practically unannounced because it is neither new or startling. It is simply our old friend High Temperature who grew about 200 deg. F. almost overnight. After Detroit Edison nursed it along from the bottle stage for some time, the novelty wore off and progress went unnoticed. During the depression the industry spent all its pent up energy in developing the youngster and of recent months announcements of new plants show that plant design is going through a major shake-up.

These changes will not mean so much in fuel economy, but they do mean a decided simplification and lower first costs through the elimination of reheat. Temperatures of 800, 850, 925 deg. F. mean decided changes in plant layout and almost a score of new high pressure plants have been announced recently, many of them in the industrial field which now stands firmly on its own feet and treads its own course independent of central stations, although the influence that one branch exerts on the other cannot be neglected.

The potential building capacity in the power field stored up by curtailed activity during recent years is tremendous. The gates have been opened already and the full flood will break during the coming year. This review issue brings plant practice to date and even takes a peek into the future so that those engineers, who find themselves faced with the task of building new plants, will be in a position to set standards of cost and performance by which the new plant must be judged.

The Diesel Acquires a Publicity Manager

AFTER STRUGGLING along manfully for a third of a century and carving a permanent niche by merit alone, the Diesel was discovered by Big Business. The newspapers were let in on the secret and now to the public the Diesel is the St. George who slew the Dragon of railroad conservatism and single-handed revolutionized rail passenger transportation. While much of what the Public has learned of the development is wrong and much of the credit should go to the metallurgical field, the publicity has been beneficial and opened the eyes of industrial executives to a form of power which deserves serious consideration.

Although sprouting wheels and wings, the Diesel is fundamentally a complete power plant. While there will always be competition between steam and diesel plants in a certain range size, the engineer should not forget that the Diesel is fundamentally a power generating machine with comparatively small heat recovery potentialities but with a flat heat rate of perhaps 12,000 B.t.u. per kw. for all sizes. A steam plant on the other hand can reach this figure only in large and complicated units but reaches its maximum efficiency when supplying heat with power as a byproduct. Full advantage is taken of these varying characteristics only when the two are used together in combination plants. There is a real future in this type of plant and its only competition will be closer coöperation between industrial plants and utility systems on power interchange.

New Year's Offering

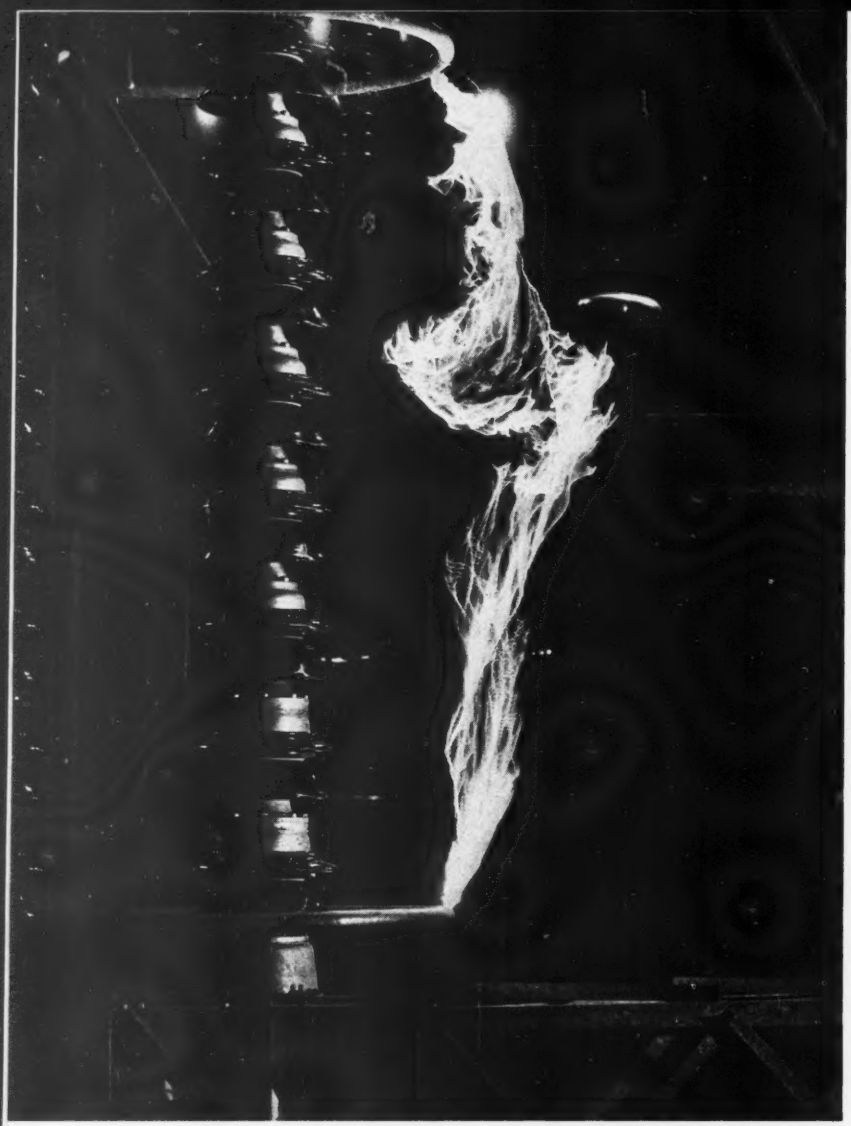
WHEN OLD Father Time turns over his hour glass and thus signs the death warrant to the year 1935 he may well say: "Your contribution to the art of power generation places you high in the ranks of industrial history." For the past year has been one in which many ideas, conceived in previous years, have developed into successful material accomplishments. The course from the inventor to the scientist to the engineer to the industrialist who controls the practical application of an idea is beset with many difficulties that often times cause retracing of steps and the resulting application frequently becomes an experiment of doubtful value for reasons of economy, safety, reliability or even obsolescence.

Charles F. Kettering has estimated that it takes an average of four years for an idea to get across the table of a board of directors from the time it is first presented as a policy to be adopted to the time it is put into effect, which is an indication of how slowly the minds of even the leaders of industry react when cooperative and coördinated action is essential. Progress in the art of power generation is subject to these same delays, but, now that the fundamental concepts of advanced practice have been proved successful in a number of installations, there is evidence that power plants, generally, will rapidly be taking advantage of economies offered by new heat cycles, higher pressures and temperatures, new water treatment processes, alloys of metals for specific purposes and numerous pieces of manufactured equipment designed to reduce losses, increase safety and reliability.

The new year opens with an offering of many recent fundamental developments that have been tested in practical applications, and their advantages and limitations are fairly established. This issue is a recital of the accomplishments in the field during the past year and is presented to you readers of Power Plant Engineering with the hope that it may add information to your personal equipment which will aid in making important decisions throughout the year to come.

Yearly Index

Index for Volume XXXIX of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.



Highlights

An 830,000 v. sustained arc-over on a Boulder Dam disconnect switch under test at the Ryan Laboratory, Stanford University. (Photo, courtesy Stanford Associates)

THROUGH the Ages, the progress of mankind has been measured by his increasing ability to utilize energy outside of that provided by his own muscles to do his work. This is true today, although it may seem that man has so much power at his command that at times it dislocates industry, causing unemployment. This, however, is no indictment of power itself; it is merely a manifestation of our temporary inability to use it properly. It is due to an unbalance between our scientific and our social development.

From the earliest times of which we have knowledge, man seems to have advanced continuously in the use of power. Although in manners, morals, arts, political and economic organizations there have been ups and downs that have not made at all for continuous progress, there has been a good deal of continuity in man's growing greater through larger use of power.

Each step in the ascent has given man a greater degree of possible development. The invention of fire, for example, was such a step and, at once, gave man an enormous advantage over the animals because it enabled him to exercise some control over his environment. These steps forward in the use of power have, in each instance, made a great difference in the affairs of man, resulting, perhaps in the difference between survival and extinction of races or between the rise and fall of a civilization.

Of man's major inventions for the control of energy, only two were made in historical times. One of these was the use of expanding gases or vapors as a source of power, as in the steam and internal combustion engines; the other was the generation and transmission of electrical power. Together, these two discoveries have, in a short space of time, less than 200 yr., made the world an entirely different place in which to live. They have increased the range of man's action and his control over his environment so enormously that today he finds himself in a daze. It does all come about so rapidly that he does not realize its true significance. In these two lie the advantages of the western world.

Prior to this era, mankind was almost entirely dependent upon the muscular power of man and animals. As late as 1870, in this country there was only 1/5 hp. per capita. Today we live in a world of 25 hp., or even in cities up to 100 hp. per capita with a population five times that of a century ago. This great increase in the availability of power is largely the cause of our present dilemma. Man has suddenly come into a 100-hp. world, with industrial, social and mental habits adjusted to a 1-hp. world. We have the power but we do not know how best to use it for the advantage of society.

This may seem a strange condition of affairs in a world generally considered to be scientific, but while science has largely produced the material side of civilization, scientific method as applied to greater understanding of man and the world has so far had little influence on man's character or behavior in the aggregate. Individuals are influenced, but society as a whole has little conception of scientific observation and experiment in the control of its affairs.

What, you may ask, has all this to do with power or specifically with a resume of the year's developments in the field of power? Only this, that in any consideration of power these days we seem to be confronted with certain elements outside of power and

of the Year's Power Activities

that unless we are familiar with these basic factors of our civilization we can never hope to attain a proper understanding of the problem as a whole. If our power problems involved only the physical question of plant and method, there would be no reason for discussion. Modern scientific method and engineering resources are entirely adequate to cope with any technological considerations that may arise regarding power. It is only when we consider power from the social standpoint that we meet with divergence of opinion, prejudice, confusion and misunderstanding. Today, power is inevitably connected with politics and social organization and any intelligent discussion of one of these factors necessarily involves the others.

From this standpoint, unquestionably the past year has been one of the most notable in the history of the power industry. Conflict of opposed concepts as to finance, economics, political ideals, social control and engineering has been vigorous in all quarters. At the same time, the rising load curves, the intense technological development, the improved efficiencies of operation have shown that power as an entity, as a growing force has a significance of its own and that its development is to a certain extent inevitable, regardless of the social order prevailing. The industry, as reflected by the rising load curve, has suffered no material damage and is in excellent condition.

Throughout the entire year the load curve has shown a remarkable increase and, since the early part of June has consistently exceeded the highest previous year's level, i.e., 1929. Early in October it equalled the all-time peak, which occurred in the latter part of December 1929 and, since that time it has steadily gone higher.

While this has been due, in part, to better industrial conditions, it is largely the result of a great increase in domestic load. As shown by the revenue curve of the electric light and power industry in Fig. 4, the domestic curve has shown a steady rise since 1929, although the wholesale power curve and the curve representing commercial lighting and small power went down until some time in 1934, when they took an upward trend.

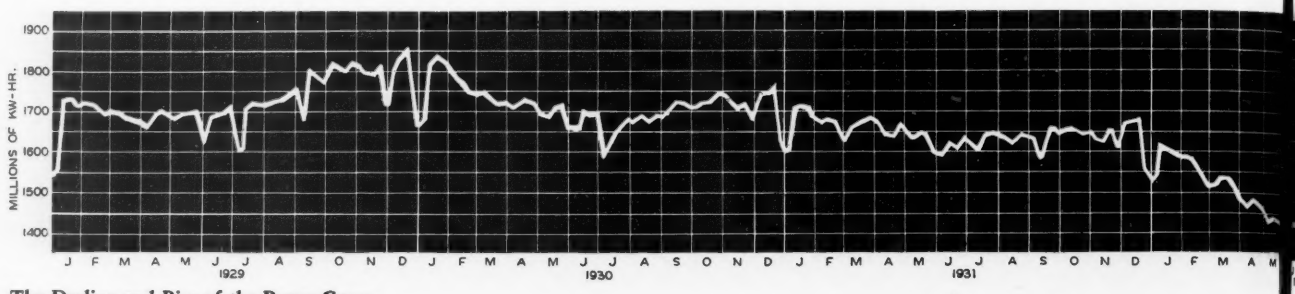
Rapid increase in domestic, rural and institutional load has reduced the margin of capacity over demand and the National Power Survey, in its report early last year, implied a possible shortage of power in the future. The report admitted an excess of generating capacity in this country from a short range point of view, but looking ahead, it implied that loads would outstrip capacities before plants could be built, unless such building was started promptly. The demand for power, it was claimed, would be at least 4,000,000 kw. in excess of that generated in 1929, a capacity equivalent to that of some 50 large generating stations.

These assertions were promptly refuted by several spokesmen of the industry who showed excess of 20 to 40 per cent, which would be increased by the federal projects now under construction. They claimed that shortage of capacity was a fallacy that could not be supported by the history of the industry and in this they were probably correct, as those in charge of the power plants of the country have never failed to keep capacity and engineering developments well ahead of needs. But the assertions as to reduced margin of capacity over demand was probably true and, during the past few months, many have been urging the addition of capacity to forestall the possible shortage which they had previously denied.

One major event of the year was the passage of the so-called Public Utility Act, which had its inception in the Wheeler-Rayburn Bills. Proposed as a means to prevent financial and economic juggling of holding companies, these bills were claimed by their opponents to be a death sentence to all holding companies within a space of 5 yr. In the compromise form, dissolution of holding companies was left somewhat to the discretion of the administrator of SEC, but the features which give the Government power of almost life or death by their power to regulate the activities of operating com-

Night view at Grand Coulee Dam Project. (Photo, courtesy Bureau of Reclamation)

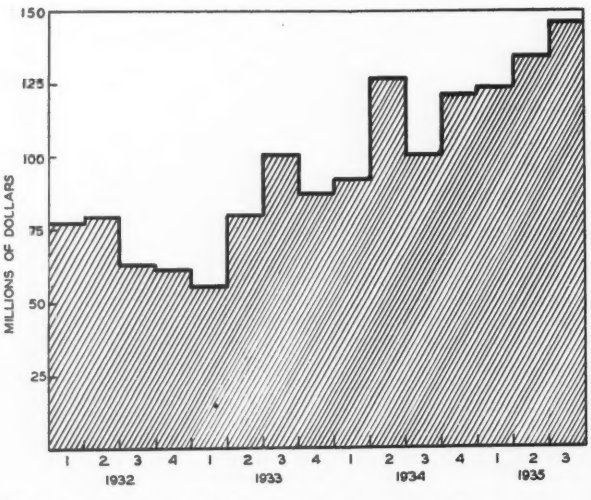
panies were retained and are of quite as great importance to the industry as the much argued death clause for holding companies. Passage of this bill was immediately followed by concerted action of the utility interests to test its constitutionality, as well as that of other activities such as the municipal loans and the TVA. The first important suit was that against the Public Utility Act, begun in the U. S. District Court at Baltimore, in which a decision was handed down in favor of the plaintiff, holding the act invalid in its entirety. It was purely a test case and will be carried to the higher courts but the decision was hailed by the utilities as a victory, although the Government is considering it as only applicable to the company bringing the suit and is enforcing the provisions of the act with regard to all other companies. The final outcome is, of course, in doubt. The tendency of the courts seems to be to uphold the validity of the Constitution and to rule that laws which confer unlimited and undefined powers upon an individual or a bureau are unconstitutional.



The Decline and Rise of the Power Curve

Of only slightly less importance is the activity of the Public Works Administration in constructing plants and making loans and grants to municipalities for power purposes. Questions connected with the PWA and TVA activities are involved and go far beyond the specific element of power control, in the struggle for supremacy between Government and vested interests. From a purely engineering standpoint, there can be little criticism of the privately owned utilities, but as to financial manipulation and the influencing of public bodies it is asserted that there is much to be criticized and that government regulation has failed to regulate. As a result, the new governmental policy is broadly directed at supplementing regulation by the force of actual or threatened direct government competition as a means of forcing electric service in the interest of the public. This involved building and operation of "yardstick" or "birch-rod" plants to enforce the demands of the government officials.

As to the yardstick effect, if the result of the most widely discussed of these, the TVA is to be taken as a criterion, it would seem to be little more than a threat and the basis for a political slogan, since the accounting and engineering practices are so entangled that they are impossible to follow and the basis for rate making is variable and indeterminate. These activities, however, whether or not started for political reasons, have materially aided the consumption of electric power and as stated by G. C. Estell, "Lots of this front page and radio propaganda is certainly detrimental to our companies as such, yet this publicity has made the public desire to use electricity for more services than ever. It has tended to make the residential user think of his electric bill rather than his light bill. . . . Today there are also available to customers cheaper and better electric appliances than ever before and our industry has its greatest opportunity to extend the use of electricity in the home." Even in the Tennessee valley region, the domestic load curve of the private utilities has shown a rise larger than in most parts of the country.



Electrical orders treble 1932 values. Graph, showing values of orders for electrical goods 1932 to 1935

In regard to the "birch-rod" effect, Vice-Chairman Manly of the Federal Power Commission announces rate reductions totaling $47,000,000 in the 12 mo. ending June 1935. How much of this might have been given because of better generating and transmission methods, regardless of the activities of Government is uncertain, but in the case of New York City, after blocking a 6 per cent rate cut in the courts, and the filing of revised schedules that involved considerable increases, the starting of plans for a municipally owned system brought a reduction of some $2,426,000 in the city electric bill and a saving of some $18,000,000 to private consumers over the proposed new schedule. In the cases of other proposed municipal plants, litigation, adverse votes on bonding and rate reduction because of the proposed plants have stopped or held up construction, so that in the end the number of these plants to receive PWA loans, and affected utility systems will

be small, but the threat of these plants has caused rate reductions so that PWA has probably been a larger factor in the "yardstick" campaign than has TVA. A recent PWA release states that a total of 44 non-federal power and light and related projects involving loans and grants of $2,709,000 have been completed and that 48 involving a total of $38,340,000 are under construction.

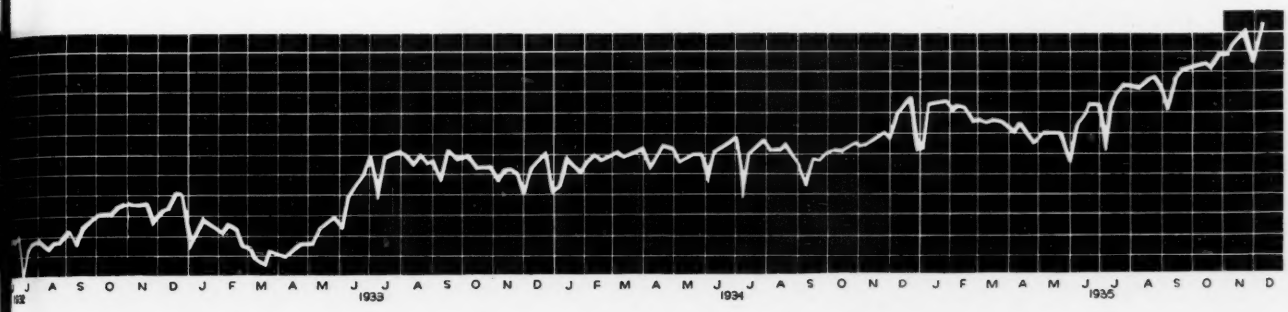
The effect of FEHA loans to industrial plants is yet to be seen but, as the maximum is $50,000 and the terms comparatively short, it is likely that most of the activity will be rehabilitation in small plants.

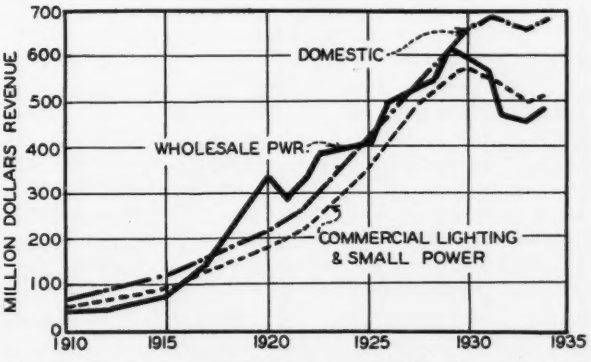
In regard to financing, the Securities Act seems not to have seriously interfered with the refunding of bonded indebtedness in most cases, although it has resulted in difficulties in some instances. The information which has to be furnished is, however, so voluminous that it is doubtful whether it is of much assistance to the ordinary investor. In the case of the Commonwealth Edison Co., the prospectus was a 69-p. booklet 8½ by 13 in., half of it financial statistics. The 33 p. of explanatory matter and maps have, however, so good a picture of the solid strength of the company that it had no difficulty in selling the issue. On the other hand, the Securities Act may have been responsible for the inability of other companies to float refunding issues. In these cases the outcome will probably result in stronger financial and management set ups.

During the past year, the Rural Electrification Administration has been set up to establish and administer a program of projects for generation, transmission and distribution of electric energy in rural areas. The projects are to be self-liquidating and may be initiated by those to be supplied or by a utility company, mortgages on the lines or pledges of the utility being taken as security for loans at 3 per cent. The amount available is $100,000,000 and the director, Morris Cooke, has implied that the work will be to a considerable extent in the supply of power from the government plants such as Grand Coulee, Fort Peck and TVA. Even though the lines will likely be of less expensive construction than has been considered advisable by private utilities, the amount available would not seem to be a threat to the activity of private rural line development. An interesting development is a new paper insulated, copper shielded cable to be plowed underground by a specially designed cable plow. Surveys are in progress in Iowa, Masachusetts, Virginia and the northwest as to the feasability and desirability of lines and many projects have already been approved.

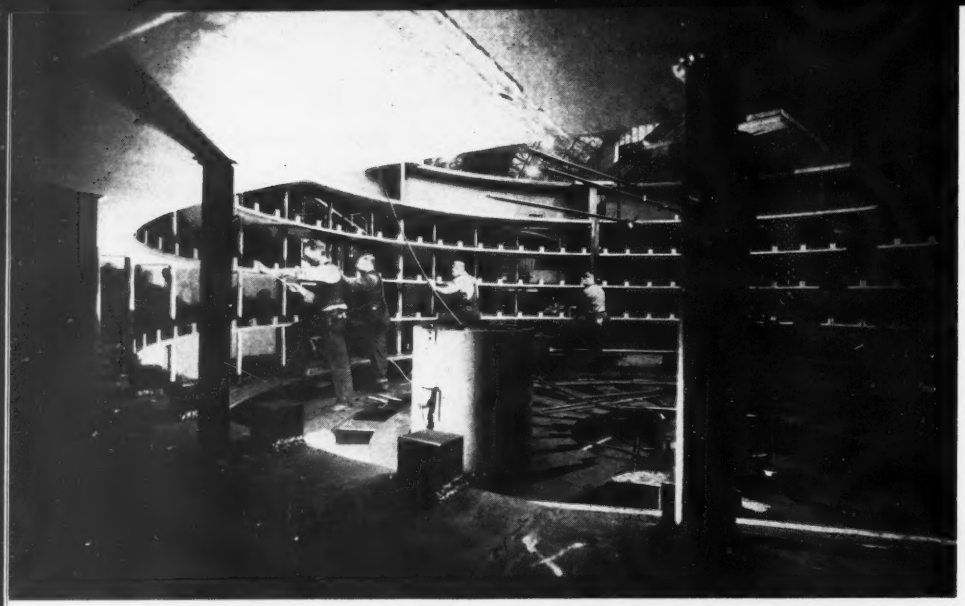
From the history of the Federal hydraulic power projects and the reports of engineers on them, it would seem that they may be regarded, except where they are essential features of a flood control system as in the case of the Fort Peck plant, as experiments in social planning of either the "yardstick" or "birch-rod" variety or in government management of industry. So far as the cost is charged off to navigation of doubtful probability or to irrigation of doubtful advisability, they are not true bases for determining reasonable rates. Also their special privilege in the way of low, if any taxes and low interest rates puts them in a different situation from a privately owned plant, which is subject to continually increased taxes and to pressure for additional free servicing of connected equipment and lower rates. Whatever may be thought of these projects socially, politically or economically, their engineering excellence cannot be questioned and, it should be noted that in one case, the Verde project, after it was rejected by the Government, was financed by private capital. The Hoover Dam development is being finished well ahead of time. The first water ran into it on February 1; work on the power house and transmission line is well under way and it is likely that the generators will go on the line early in 1936, though some of the customers who have contracted for power are asking that the delivery be delayed as their demands have not developed as expected.

In the Tennessee Valley, work on the Wheeler, Norris and Pickwick Landing Dams is progressing according to schedule. At Wheeler the first 45,000 hp. turbine is being erected and the generator will be delivered during the first quarter of 1936. In any consideration of the power projects of the TVA, it must





Curves showing commercial, wholesale and domestic power loads



Inside of the stator frame of a Boulder Dam Generator. (Photo, courtesy Westinghouse)

be understood that these are only incidental to the much greater task of the social rehabilitation of the valley.

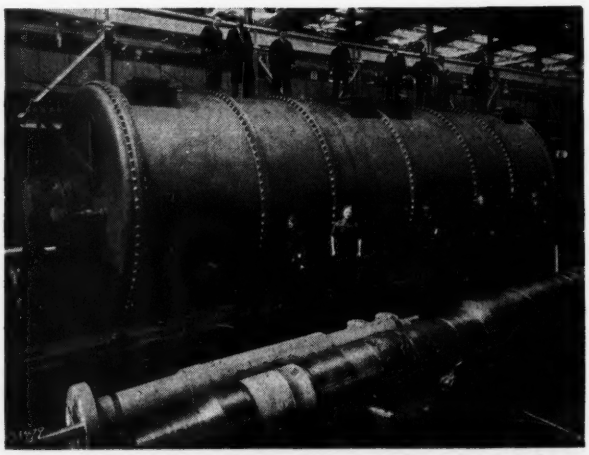
Other projects are progressing but it is unlikely that any of them will be in condition to furnish current before 1937. Last of them to be started, the Passamaquoddy Bay tidal plant will be a long time in getting into service, and the question of whom it will serve seems quite uncertain in view of the Maine laws in regard to export of power from the state and the isolated location of the development.

Report of an electric rate survey during the year showed the differences which might be expected on account of the difference in the size of the cities surveyed and the conditions but the variation between highest and lowest is wider than seems reasonable. For cities of from 50,000 to 100,000 population, the low rate for 15 kw-hr. is 60 cents while the high is $1.66 and for 100 kw-hr. the low is $2.73 and the high is $7.31. It would seem that much of the dissatisfaction with rates could be eliminated if some simple method of rate making could be established and universally used so that the customer could understand the basis on which the charges are determined and the factors which enter into making up the rates.

Rate Survey

Controversies in regard to rates and between advocates of private and of government ownership and operation of utilities are not confined to this country. They are world wide and are hedged about by prejudice and opposing philosophies of government, which hampers or precludes the scientific investigation and impartial consideration of facts. It is encouraging to note, however, that with all the difficulties with which the industry is beset, it is advancing steadily in all phases. Manufacturing companies, almost without exception, report greatly increased sales and profits. Load is steadily increasing. While no great amount of new steam capacity was added during the year, the 165,000-kw. addition to Richmond Station and the new Port Washington Station are significant of what is coming. Progress during the year may well be characterized as the crystallizing of scientific research and engineering thought that has been developing during the past several years. In spite of deterring conditions, industrial plants have carried on quite an active campaign in modernizing their equipment. Higher grade engineering has entered into selection of equipment, especially in fitting the power plant to the exact needs of the industry which it serves. In many cases this has resulted in superimposing a higher pressure steam generating unit upon a plant of lower pressure, resulting in steam cycles which fit the specific conditions more nearly than was the case in the old plants. Bleeder units are extensively used, fuel burning equipment is of the latest type, with automatic combustion control. On the average, steam pressures are increasing and steam generating and using equipment are becoming somewhat standardized to fit modern pressures.

New methods, new ideas, new heat cycles are being discussed at engineering conventions, which will result in lower costs of construction and operation. These will enter into the solution of the problem of greater distribution and use of electric power in every project to make the world a more comfortable place, more appropriately fitted to meet the needs and desires of mankind.



First Hydrogen Cooled Frequency Changer. Machine rated at 22,222 kv-a. converts 3 phase 60 cycle power to 25 cycle, 3 phase power at the Bethlehem Steel Co.'s plant at Bethlehem, Pa. (Photo, courtesy General Electric)

The Plant Today

(Photo, courtesy Austin Co

AFTER A CENTURY and a half, an almost unbelievably effective system of power generation has been evolved. This system embraces units ranging from small internal combustion engines of a few kilowatts to steam turbines of several hundred thousand kilowatts of capacity all operating within a narrow band of efficiencies undreamed of by Otto and Watt. It is questionable if any of the early pioneers, except possibly Jacob Perkins, appreciated the trend of development and he, generations ahead of his time with his ideas rendered impractical by the inadequacy of materials then available and hampered by inadequate data on the properties of steam, could not possibly have had more than a suspicion of the truth. In fact it is questionable if engineers of even a decade and a half ago suspected that plant heat rates would be cut in half in a few short years.

In America the boiler pressure ranges have been well standardized with 300 to 400 lb. for smaller plants, 800 lb. and 1400 lb. for the larger sizes. Temperatures range from 650 to 1000 deg. F. with about 850 as the upper commercial limit. At present for new utility plants an 800 or 850 lb. pressure, 850 to 900 deg. F. cycle without reheat would probably be favored but it is likely that the greatest development in this field will be the addition of "high pressure tops" to existing plants, that is 1400 lb., 800 to 900 deg. F. turbines, exhausting to existing machines. In the industrial field, conditions are fixed largely by the ratio of power to process heat demands and generalization is more difficult.

High rating, high pressure units, usually have water cooled furnaces and are fired either by pulverized coal or underfeed stokers. Great progress has been made with slag tap furnaces for both industrial and central service while stoker and furnace design has progressed so far that even the lowest grades of coal can be burned successfully at reasonable ratings. In this development air cooled walls have not lagged behind and the lower investment involved makes them attractive with the lower priced moderate pressure boilers.

Extraction is now universal and many industrial plants find extraction and back pressure turbines advantageous for process use. By eliminating the condenser loss completely the overall efficiency is raised so high that the power cost consists almost entirely of fixed charges. The big field yet remaining is closer

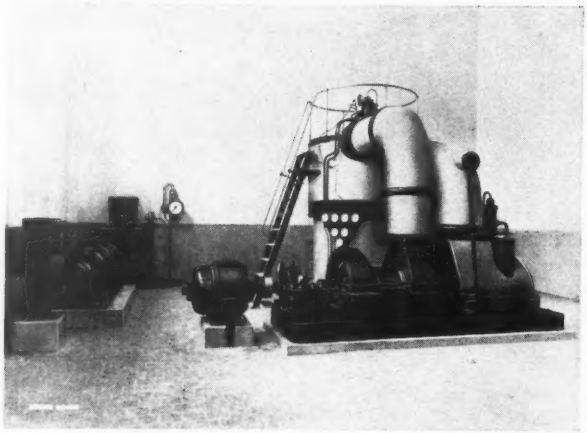


Fig. 1. The Velox Boiler—utilizing high velocities to obtain high heat transfer rates. (Photo, courtesy Brown-Boveri)

coöperation between industrial plants and public utility systems.

The principles involved, high pressures, high temperatures, reheat, regeneration and binary vapor cycles are not new, but, due largely to advances in metallurgy, these practices have been made practical, although unfortunately, the industry cannot as yet agree as to the best method, or, combination of methods, for meeting specific requirements. As a matter of fact, the breach between various factions has widened of recent years.

Progress comes only with action and the almost static condition of power plant construction during the past two or three years has broken up the orderly progress of the industry and left chaos in its wake. At the beginning of the depression the 1400 lb., 750 deg. F. reheat-regenerative cycle stood head and shoulders above all others. Designers of new stations were almost unanimous in their choice as evidenced by Lakeside, South Amboy, Gilbert, Station A and Deepwater built during this era. The trend was so strong that the intermediate pressures were eliminated so completely from the central station field that plans for an addition to State Line called for an increase of from 800 to 1400 lb.

True, there were the incorrigibles who, while admitting the immediate justification for such developments, persisted in breaking their own trail toward the goal of ultimate economy. Detroit Edison was one of these and their persistence in thoroughly exploring the high temperature field is largely responsible for the trend toward lower pressures and higher temperatures for the purpose of eliminating reheat. Another such company was the Hartford Electric which carried the mercury vapor plant through the experimental stage. Further installations at Kearney and Schenectady placed the mercury vapor cycle so definitely in the commercial running that faint rumors of another installation are in the wind.

Nor have European and American trends been in accord during the past decade. The Europeans, following theoretical considerations, first explored high temperatures often with highly unconventional boiler designs. The Americans continuously followed high pressures with moderate temperatures and with conventional boiler designs. Both sides, exhausting the possibilities along one line, turned to the remaining possibility. In this country high temperatures, 800 to 1000 deg. F., are now being investigated. The possibilities of high pressures up to 1400 lb. have largely been exhausted, in fact, there appears to be a trend toward more moderate pressures of 800 to 900 lb. for entirely new plants. This trend, which may or may not be temporary, is for the purpose of avoiding the expense and complication of reheat. Europe, with highly unconventional designs, continued to increase pressures up to 1800 and even 3200 lb. with boilers of the Loeffler and Benson type while super heat-transfer boilers of the Velox type, with positive furnace pressures of about 30 lb., offer interesting possibilities, over 30 such units having been built since 1932.

When discussing the Plant of Today in the light of past experience and trends, a number of factors must be taken into consideration. Some of these have become established practice during the past decade while others are still in the experimental stage subject to changes as experience and new developments indicate. Some of these factors are:

First, Fuels and Furnaces. Choice of fuels is determined largely by geographical location. In the south central and southeastern states fuel oil and natural gas ordinarily compete successfully with coal and subject to individual inherent losses may be burned with the same overall efficiency. The first two do, however, offer some advantage in control and handling which is perhaps offset by uncertainty regarding price and supply, making it advisable in most cases to design a plant for quick and convenient change over to coal.

In the rest of the country coal is supreme and the controversy of a few years ago on stoker vs. pulverized coal has died a natural death. Both have been so highly developed that either will handle any type of coal with equal facility, the choice being largely a matter of personal opinion.

Development of the slag tap furnace removed the bugbear of low fusing temperature ash from pulverized coal. It is safe to say that any coal, from the low grade lignites of the west through the low and medium grade coals of the middle west to the anthracites of the east may be burned successfully in pulverized form, the only limitation being in the economy of grinding. Some coals are not as friable as others and add to the power cost and swell maintenance expense. Again, most of the coal used for power purposes is low grade often with a high percentage of ash and slate which is both difficult and expensive to grind. Although still in the development stage much good work has been done on the determination of the grindability index from which the power requirements and mill capacities of various coals may be predetermined. Pulverizer guarantees as now ordinarily made on the basis of a coal of known grindability and the grindability index of the coal to be used have eliminated the problem of proper capacity which was troublesome in the early days before the importance of this factor was fully realized.

Burner design has progressed at a remarkable rate, a single burner of the West Virginia Pulp & Paper Co. having a capacity of 200,000,000 B.t.u. per hr., equivalent to almost 135,000 lb. of steam. That pulverized coal can be handled successfully in industrial as well as central station plants is shown by the operating rec-

ord of two outstanding plants of last year, the Hiram Walker Distillery and Goodyear Tire & Rubber.

The former plant has two 235 lb., 750 deg. F., 13,790 sq. ft. bent tube boilers and two 1875 kv.a. back pressure turbines. Two 10 t. and one 3 t. pulverizers are installed and the boiler efficiency averages 85 per cent. In the second plant is installed an 800 lb., 750 deg. F., 20,131 sq. ft. straight tube boiler (second unit being added) and a 7500 kw. back pressure turbine. The monthly efficiency averages range from 83.5 to 84.4 per cent with load swings from 55,000 to 350,000 lb. per hr.

Stoker development has been equally remarkable and covers the range from household use, burning a few pounds an hour, up to stokers for boiler units of over a million pounds of steam per hour. All coals are handled successfully perhaps the most remarkable feat of the underfeed during the past year being the successful handling of low fusing temperature ash coal by the University of Iowa and at the Cedar Rapids Railway & Light Co. In the latter plant the stokers have water cooled tuyeres. This development, extending over a two-year period was made experimentally on old stokers and the installation has successfully handled coal (1900 deg. F. ash) at the rate of 55 lb. per sq. ft. With water cooled tuyeres the molten ash freezes some distance up in the fuel bed and does not interfere with the flow of air and proper functioning of the stoker. Another development of interest is the application of sprinkling stokers to the fine screenings from coal sizing and cleaning plants which is so fine that a large proportion is burned in suspension.

Preheated air is used successfully with either method of firing, although the allowable maximum is lower with stokers than with pulverized fuel. Recent experience at Connors Creek indicates that 400 deg. F. can be handled successfully without water cooling. Widespread application of preheated air has cut in on the economizer from the gas side, while the extraction has cut in on the water side until the economizer has steadily decreased from a piece of equipment of primary importance to that of an accessory useful in some cases but not necessary because its function can be taken over by something else.

In this connection the subject of water treatment cannot be passed without comment. High pressures, high steaming rates, steel economizers and embrittlement brought up new problems in water treatment and led to a very thorough analysis of the problem. The work of Hall, Straub and Partridge stands out and although the matter is still controversial, practical water treatment has been developed to the point where real trouble crops up infrequently. Modern treatment is not confined to the boiler but must consider corrosion in the steam and water piping and deposits on turbine blades. Recent work by Straub on this problem shows that sodium hydroxide is the basic material causing blade fouling and that it is prevented by suitable amounts of inorganic salts such as sulphate, chloride and carbonates.

Furnace design is still more of an art than a science and covers the range from complete refractory to complete water cooling with every shade and gradation in between. There is no gainsaying the part that the water cooled furnace has played in the development of the modern boiler room with its high heat release

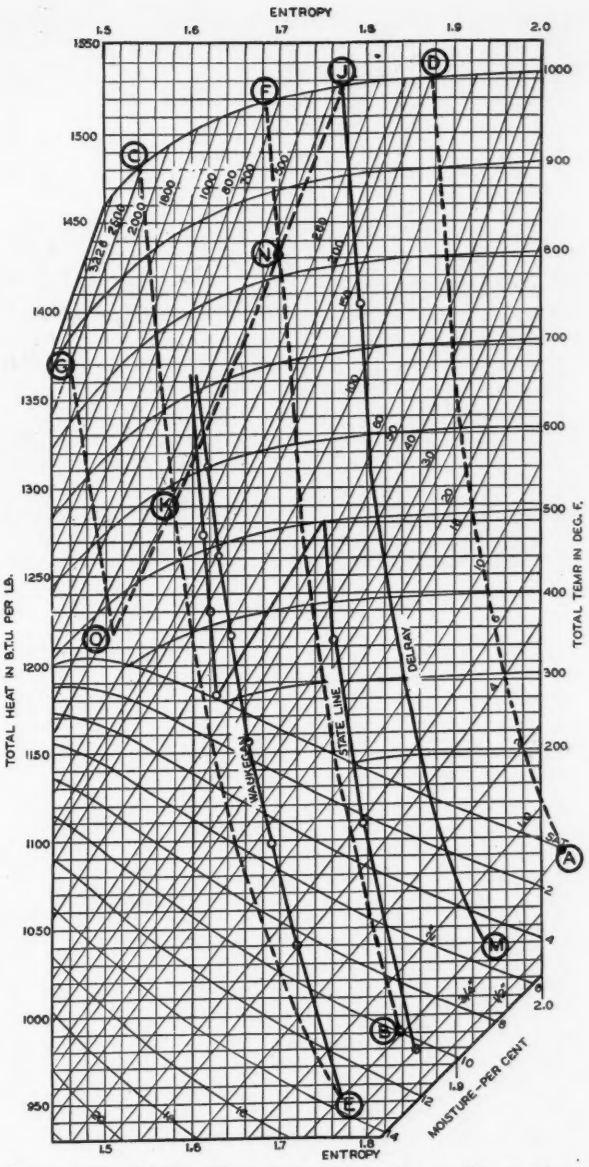


Fig. 2. The Mollier Chart shows clearly the possible trends of future plant practice.

furnace, preheated air, high heat transfer, radiant surface and successful use of low fusing temperature ash coal. The water cooled furnace is, however, expensive and it has by no means monopolized the field. The smaller and lower pressure boilers, where moderate furnace heat releases are feasible without unreasonable furnace dimensions, make extensive use of refractory, both solid and air cooled, walls, Shelby and Annapolis being recent examples of these types of construction.

Second. Extraction. Like the air heater, the extraction cycle is here to stay and its usefulness extends far beyond the feedheating cycle. In fact, for industrial service extraction ranks in importance with back pressure operation for supplying process needs at maximum efficiency. To a more limited extent this practice is applicable to central station operation for two purposes: supplying steam for heating systems, and for adding high pressure tops to low pressure stations for modernization purposes.

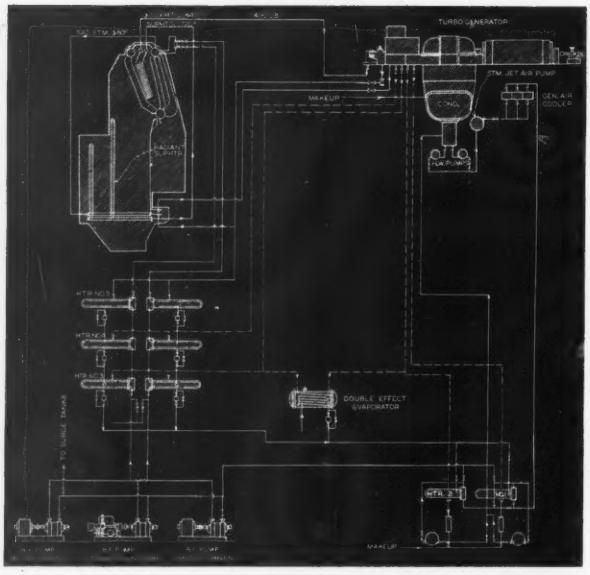


Fig. 3. Flow Diagram of Port Washington Station, the high water mark of reheat practice

For feedwater heating purposes the maximum temperature is limited by the saturation temperature of the boiler water although the cost of closely approaching this limit renders it uneconomical. Past practice with the reheat cycle has been to use the reheat pressure as the highest feedheater point thus limiting the temperature to the range of 400 to 450 deg. F. Inasmuch as the saturation temperature for 800 lb. is but 521 deg. F. and 1250 lb. but 572 and the cost of high pressure heaters is a considerable item, it is not likely that feedwater temperatures will be increased greatly over present practice.

The successful introduction of open heaters at South Amboy several years ago and their use at Buzzards Point last year opens up an avenue to increased efficiency and simplification that may be used more widely in the future. These heaters eliminate the heat transfer differential of 3 to 5 deg. F. and enable the water to be brought up to the full temperature of the steam. They also eliminate flashing losses and the need for drains but introduce need for additional control which offsets some of these advantages and, furthermore, separate pumps are needed for handling the flow between each of the heaters. Ordinarily these pumps are all driven from a single shaft but handling water at these high and fluctuating temperatures and pressures is difficult pump service. In addition a separate closed heater is necessary if advantage is taken of the high superheat in the high pressure bled steam.

Many of the previous disadvantages of the closed heater are eliminated by recent designs where by means of baffling advantage may be taken of the superheat and the drains may be cooled below the saturation temperature of the heater pressure. Closed heater control is simple, piping may be simplified by using duplicate heaters and the feed pump can be located at a comparatively low temperature level where the service is less rigorous and where appreciable saving in power can be made. Port Washington is the latest and best example of closed heater practice.

Third. Reheat, high temperatures and high pressures. These three factors are so interrelated that it is difficult to discuss them separately. Exhaust pressures are definitely fixed by condensing water temperatures and 1 in. of Hg. may be taken as the lowest average practical limit. In order to reduce the condenser loss it is advantageous to run the moisture in the turbine exhaust as high as possible but modern turbine design places a maximum limit of 10 per cent moisture. This definitely locates the exhaust condition between points A and B on Fig. 2, the vertical distance between the two representing a difference of approximately 100 B.t.u. per lb. condenser loss.

On the other hand, the present maximum temperature limit may be taken as 1000 deg. F. and by stretching the point a trifle the practical pressure limit may be considered as the critical pressure of 3226 which, allowing for piping and superheater losses, etc., gives a turbine pressure of 2500 lb. or over. This places the throttle condition somewhere along the line CD, representing a difference in total heat of approximately 50 B.t.u. Making use of published expansion lines of actual turbines (Delray on the right and Waukegan on the left), probable expansion lines from the two extremes, C and A, are shown by heavy dotted lines. DA represents a heat drop of about 440 B.t.u. at a thermal efficiency of almost 29 per cent and CE about 530 B.t.u. at an efficiency of about 36 per cent. Thus the higher pressure offers an additional heat drop of over 100 B.t.u. per pound and an increase in efficiency of around 7 per cent even though the initial heat content of the steam is less by about 50 B.t.u.

Future development in turbine blading material in separating moisture from the lower stages may make operation along the line CE practical at some future date but the lower limit of 10 per cent tentatively placed by turbine manufacturers would make one of two courses necessary: first, to reduce the initial pressure to about 850 lb. and expand along the line FB representing a heat drop of about 530 B.t.u. and an efficiency of about 35 per cent; or, second, reheat at some pressure from 300 to 500 lb. represented by the dotted line OJ. Initial conditions might be maintained at C or placed somewhere along the line CG and reheat might be carried all the way to J. For CKJM there is a heat drop of about 680 B.t.u. representing a thermal efficiency of over 39 per cent. For GOJM the heat recovery drops to about 645 B.t.u. and the efficiency to

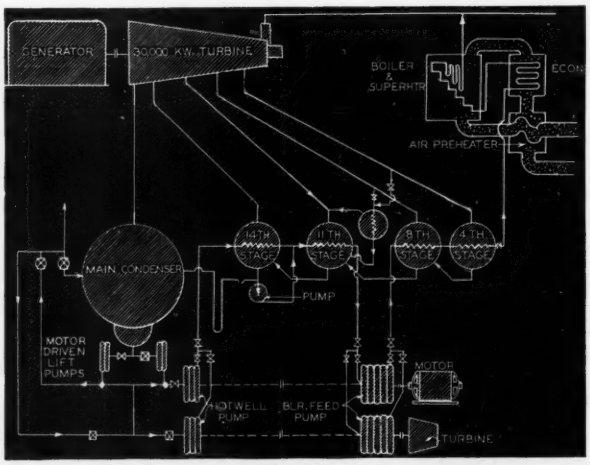


Fig. 4. Flow Diagram of Connors Creek—a modernization job that cut the heat rate from 19,000 to 13,000 B.t.u.

slightly below 39 per cent, due to the lower initial temperature, which in practice might be increased somewhat over that shown. For CKNB the heat drop is about 650 and the efficiency about 39 per cent. There is, therefore, an infinite number of possibilities offering about the same return. Considering, however, that a straight expansion from F offers practically as much, it appears, that prophecies regarding the decline of the reheat cycle are well founded. This also means, at least until the upper temperature or moisture in the exhaust can be extended, confining pressures to the 800-1200 lb. range.

These conclusions, based on certain assumptions of temperature, moisture in the exhaust, and turbine efficiencies, do not check overly well with developments in Europe where 1800 lb. and 900 to 950 deg. F. appear to have rather widespread application and where the possibilities of the Benson initial pressure boiler have been sufficiently well demonstrated to justify the acquiring of a license by an American manufacturer. For initial conditions of 2500 lb., 850 deg. F. with one stage of reheat and five stages of extraction heating the manufacturers estimate an efficiency (generator, excluding auxiliaries) of 41.7 per cent. If we assume European turbine efficiencies are not appreciably higher than American efficiencies we must consider that Europeans are not so hampered by inhibitions regarding the moisture content of exhaust steam, a logical conclusion considering the lower tip speeds due to 50 cycle current and smaller size units.

Fourth. Binary-vapor cycles and mixed plants. No review of progress can be considered complete without reference to the binary-vapor cycles as used at Kearny and Schenectady. In this cycle mercury vapor is generated in a special boiler and this vapor is used in a turbine in the same manner as steam. The mercury exhausted from the turbine is condensed in a special vessel and the latent heat given up is used to generate moderate pressure steam which is superheated and used in the ordinary way. At Kearny it is used in a condensing cycle, at Schenectady the steam is used for process use.

The advantage of the cycle lies in the fact that the cycle efficiency is determined largely by the upper and lower temperature limits. Mercury has low vapor pressure, that is the saturation pressure for a given temperature is much lower than water. Thus at Kearny the mercury vapor goes to the turbine at 125 lb., 958 deg. F. and is exhausted from the 20,000 kw-5 stage, double flow turbine at 1.3 lb., 475 deg. F. This is used to generate 415 lb. steam which is superheated to 750 deg. F. If, however, the steam cycle can be raised to the same temperature limits, the advantage of the mercury vapor cycle disappears as its complexity demands a considerable efficiency advantage to be practical.

The Schenectady plant has a similar 20,000 kw. mercury turbine together with a steam turbine and two boilers, one mercury and one steam. It is an industrial plant operated in conjunction with a utility system. It is also an outdoor plant, the forerunner of what was thought to be a desirable move in reducing first cost but which was, unfortunately, held up by the depression and it is questionable if it will ever be seriously revived on a broad scale.

The question of closer coöperation between large industrial plants and utility systems is one that will

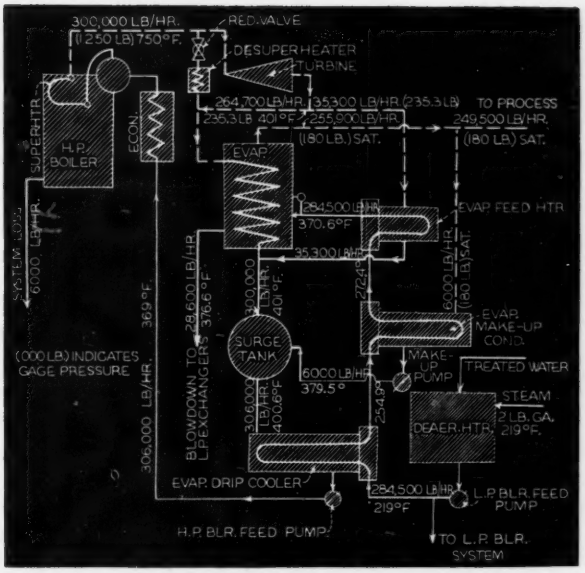


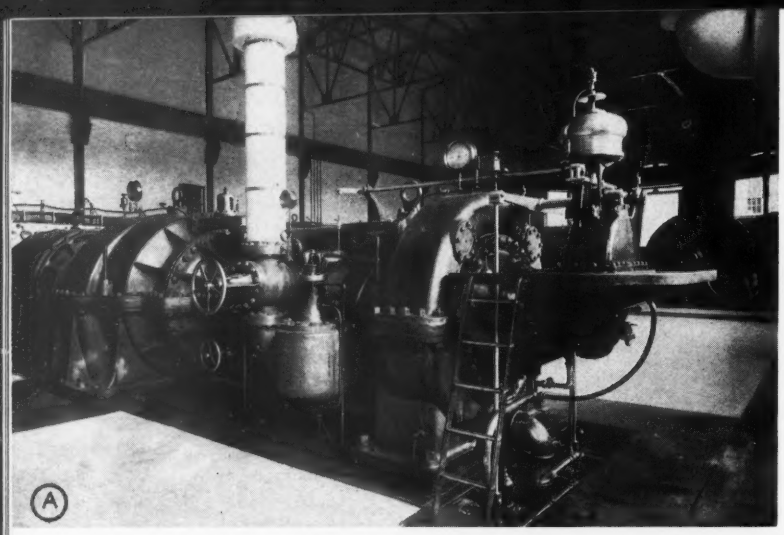
Fig. 5. Firestone Tire & Rubber plant is an excellent example of complete industrial application for process needs

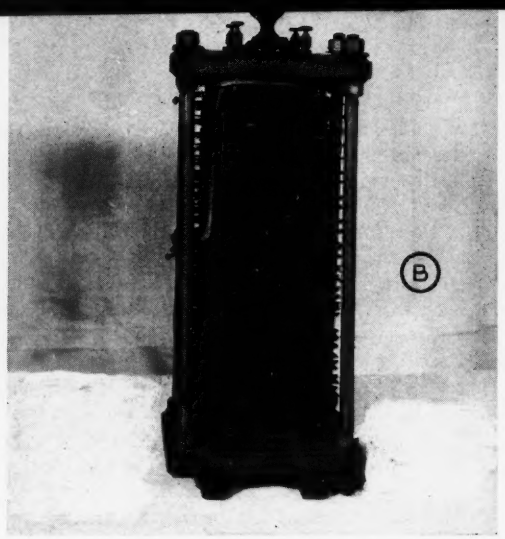
bear close study. Deep-water, Baton Rouge, Louisiana Steam Products and Schenectady are excellent examples of past practice and it is to be hoped that the practice which offers so much in increased economy will be extended.

In the absence of such coöperative measures, the Diesel engine used in conjunction with the steam plant offers possibilities. The Diesel offers a quick, convenient and efficient method of increasing electrical capacity when steam capacity is sufficient and offers considerable potentialities for the production of hot water and even low pressure steam from waste heat boilers. Perhaps the most interesting installation of this kind during the year was in the Singer Building in New York where a spare boiler and fan were removed to make room for a 350 kw. Diesel unit. This unit is operated in parallel with the existing steam units. Another example is the city of Litchfield, Minn., where a 606 kw. Diesel unit was installed to operate with steam turbines and a heating system, the engine saving approximately $30,000 in first cost over additional steam capacity.

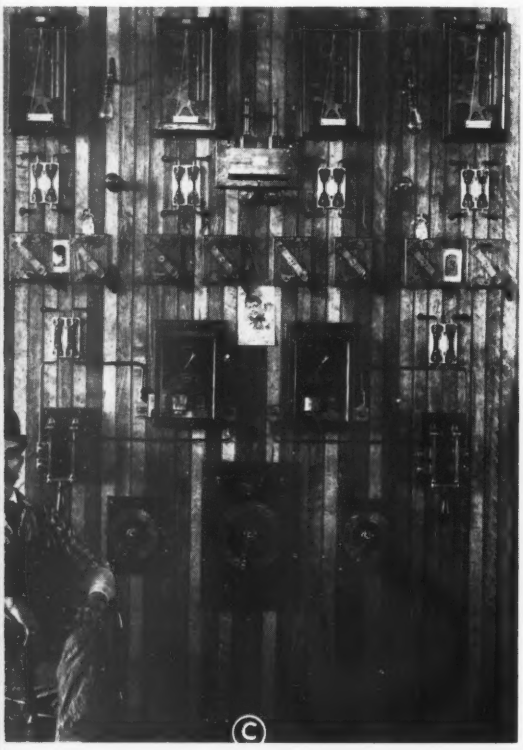
When considering the present state of the art as represented by stations recently completed it is not difficult to select representative central stations because only two were completed during the year. In the industrial field selection is more difficult but relatively unimportant because of a number of proposed stations that go far beyond present operating conditions.

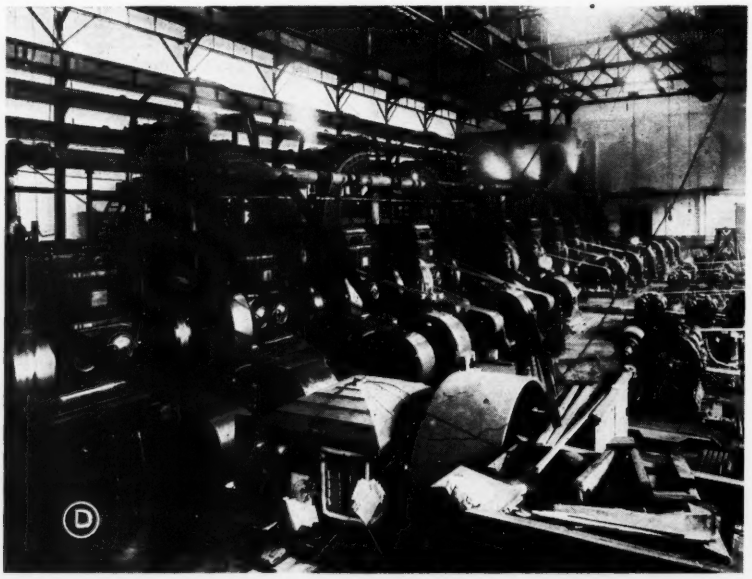
The fact that Port Washington is the only new central station to go into service in 1935 should not detract from the position of the station in the field. In any year, among any group of stations, Port Washington would be assured a prominent position and well deserves the title of America's Premier Station. It represents the "simplified unit plant" toward which the industry has been working of recent years, a single boiler, single turbine plant of low first cost and high efficiency. Furthermore, it is the culmination of two decades of development and pioneering work by a single company to which high pressures, reheat, pul-



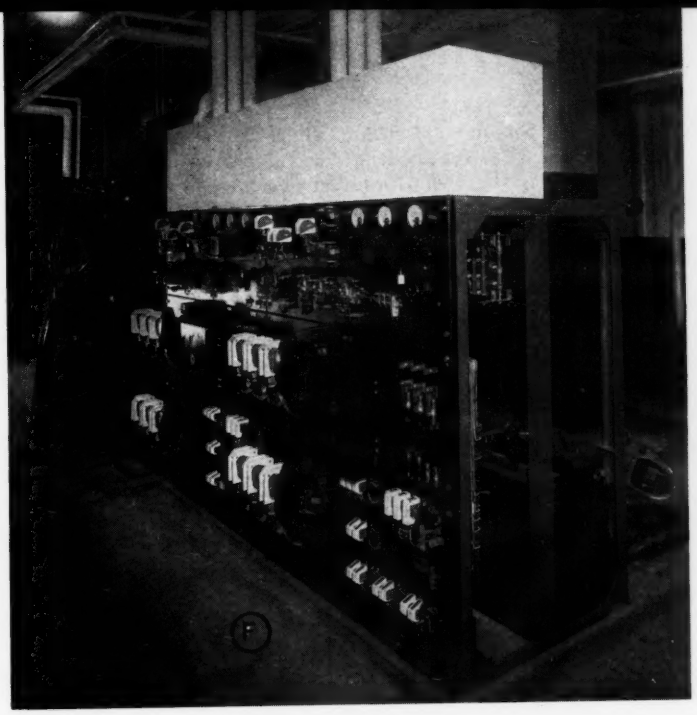


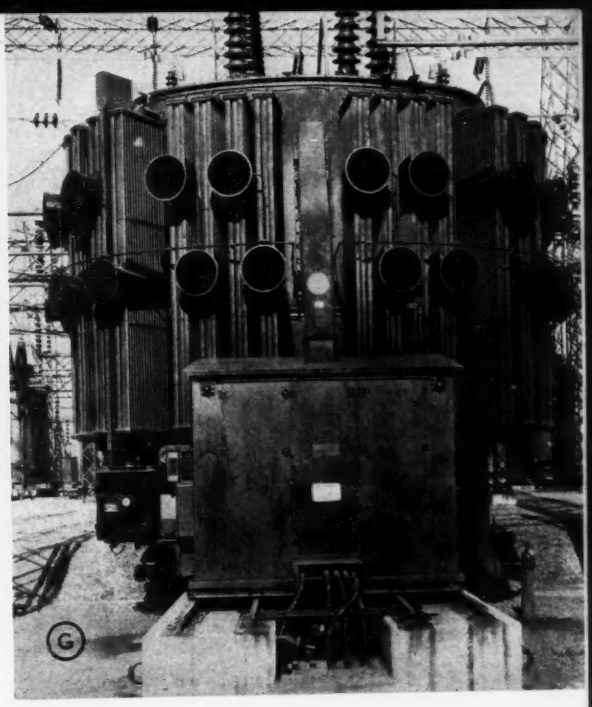
The Plant of Yesterday



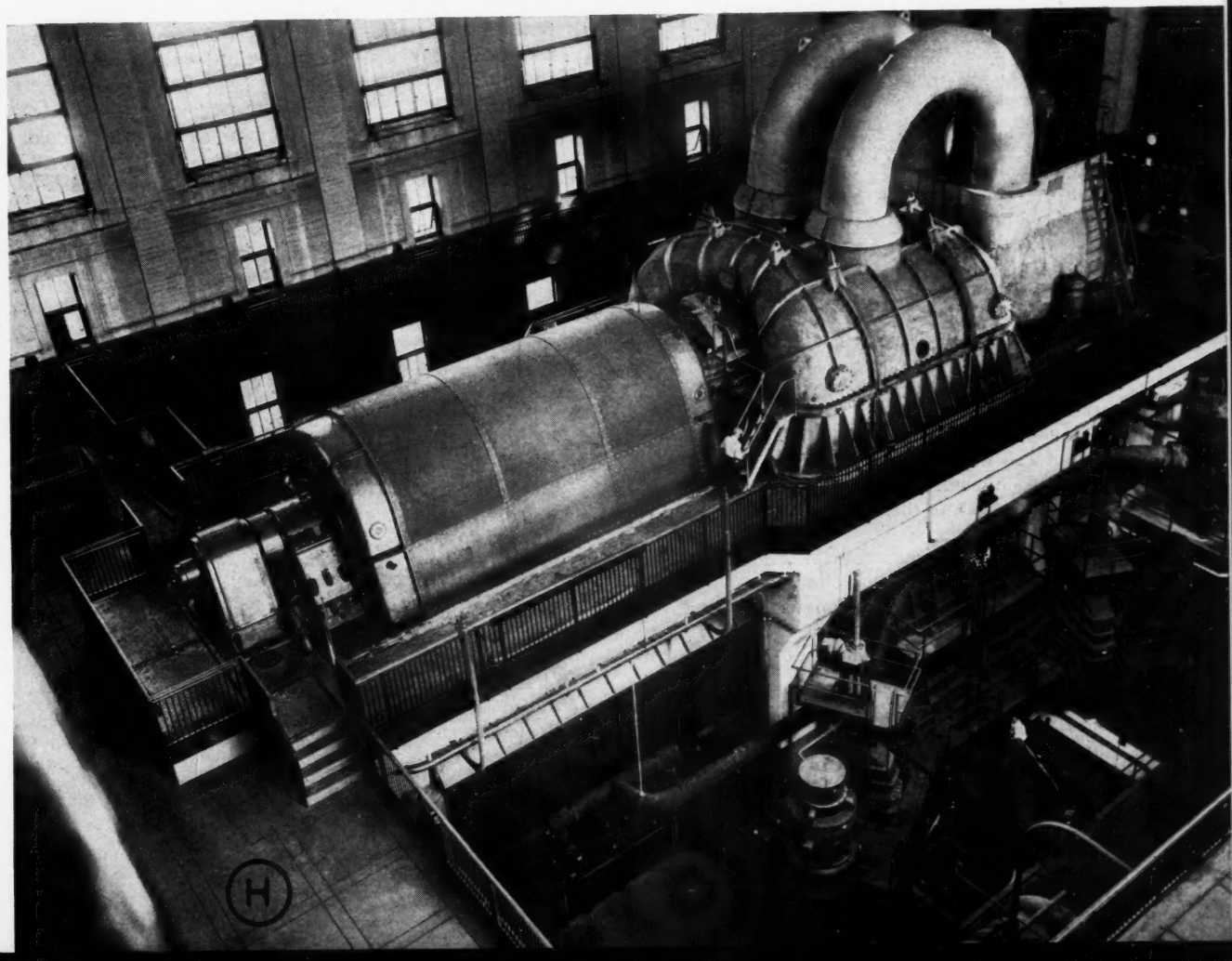


An old Chinese proverb maintains that a single picture is worth ten thousand words. Looking at these pictures we can well believe it—it would take at least 80,000 words to tell the story represented by these photographs which were furnished to us by Westinghouse in connection with their 50th anniversary this year. At A, is a view of one of the first turbogenerators, that of the Hartford Electric Light Co. This machine it will be seen was already quite well developed and a great advance over the early electric power plant shown at D which is that of the Allegheny County Light Co. in Pittsburgh. But compare both of these installations with that at H, the 165,000 kw. unit at Richmond, the largest single element generating unit in the world with its 113,000 sq. ft. condenser, also the largest. At B is shown the secondary converter developed in Europe by Gaulard and Gibbs. This was the forerunner of the transformer, shown at E and which was a part of the first practicable installation of alternating current, made at Barrington, Mass. Compare this with the enormous transformer of today shown at G. At C, we have the switchboard of 50 yr. ago when it was really a board with switches on it. A high development of today in switching and control equipment is the angle switching equipment for synchronous motors as shown at F.





The Plant Today



verized coal, modern water treatment and radiant superheaters owe much.

Whether reheat remains or passes from the picture, this station represents the high water mark in which reheat complications and expense have been cut to the irreducible minimum, the piping between the turbine and boiler and the additional cost of alloy turbine blading and radiant reheat elements. Control of temperature is handled in the logical manner by proper selection of equipment characteristics which eliminates the elaborate control systems often used for this purpose. The station has one 690,000 lb. per hr., 1400 lb., 850 deg. F. boiler and one 80,000 kw. turbine.

Many Other Features

Aside from reheat, however, there are other features worthy of close study. Extraction heaters of a new type with improved heads and baffling to take advantage of superheat in the steam and to reduce flashing losses installed in duplicate sections so as to eliminate the necessity for bypass and thus simplify piping. Boiler feed pumps handle comparatively cool water at an appreciable saving in power and maintenance on the pumps. A single boiler is installed with superheat and reheat characteristics which eliminate the control problem. A modified bin system of firing is used with flue gas mill drying, an arrangement which makes it possible to shut down the mills during peak load and increase the net station output.

Another event of importance was the rebuilding of Connors Creek Sation. This was originally a 225 lb., 600 deg. F. station about 20 yr. old. The heat rate of 19,000 B.t.u. was cut to about 13,000 by rebuilding for 700 lb., 825 deg. F. Four 330,000 lb. per hr. bent tube boilers, fired by double ended underfeed stokers and three 30,000 kw. turbine units are installed. It is significant that this modernization program, carried out after pioneering work with 1100 deg. F. steam, was limited to 825 deg. F.

It is probable that the major capacity additions of the utility industry will be remodeling of this type, either complete rebuilding of very old plants or the addition of high pressure tops to more recent stations. A study of the Public Service system in New Jersey showed that to this system, totaling 685,000 kw. of capacity, some 200,000 kw. of superimposed and 500,000 kw. of incremental capacity could be added before new stations need be built. This doubling of the system capacity can be made at from 80 to 90 per cent of the cost of new stations.

Of course each plant or system has its specific problem but the need for low cost and high efficiency is general. Condenser water is another problem to many inland plants and to these new tops are doubly helpful. Millers Ford station at Dayton reached the limit of its capacity last year when for the first time the entire flow of the river was utilized for this purpose. A new high pressure turbine superimposed on the old station is being planned to add 25,000 kw. of capacity and increase the efficiency without adding to the condensing water requirements.

At Cedar Rapids where the power plant supplies a central heating system, a 700 lb., 765 deg. F. boiler and a high pressure turbine exhausting at 210 lb. to the main header were installed, cutting the station heat rate to 11,200 B.t.u.

Richmond extension, where the steam pressure of 400 lb. was retained but the temperature was raised to 850 deg. F., was of interest in modernization programs due to the fact that advances in design made it possible to install 165,000 kw. in space originally intended for 50,000 kw. Two 600,000 lb. per hr. pulverized fuel fired boilers and one 165,000 kw. turbine are installed. The condenser with a surface of 113,000 sq. ft. is the largest yet built.

It is difficult to class Ford's River Rouge plant as industrial because its size and requirements approximate those of a central station. Construction there, however, always means an innovation, the most recent addition being the addition of another 110,000 v. vertical compound turbine using steam at 1200 lb., 900 deg. F. and chromium plated in accordance with Mr. Ford's contention that the power plant should be decorative as well as utilitarian. This increase in temperature over 725 deg. F. of the older unit eliminates reheat and cuts the turbine heat rate from 9675 to 9000 B.t.u. Boilers fired by pulverized coal and gas have a remarkable flat efficiency curve; 87.7 per cent at 400,000, to 87.8 per cent at 600,000; 87.4 per cent at 800,000 and 86.6 per cent at 900,000 lb. per hr. A 15,000 kw., 1200 lb., 900 deg. F. turbine operating at 250 lb. back pressure will also be installed, a sizable unit in itself in any other industrial plant.

As an example of complete and effective use of modern equipment in industrial plants, the 1250 lb., 750 deg. F. Firestone installation completed early last year is perhaps as complete as can be found, involving not only a 10,000 kw. high pressure turbine exhausting at 250 lb., but an industrial evaporator or heat transformer as well, the latter used for supplying process needs, without contaminating the feedwater cycle.

Up to 925 Deg. F.

Other stations, following more or less conventional design, are so numerous that space does not permit discussion, particularly in view of the rapid increases in temperatures indicated by newly announced plants. For instance, Weirton Steel is building a plant with 900 lb., 815 deg. F. boilers and an 800 lb., 800 deg. F., 12,500 kw. turbine exhausting at 215 lb. An 850 lb., 825 deg. F., 12,500 kw. non-condensing turbine is being added by the Virginia Electric & Power Co. and a 40,000 kw., 3600 r.p.m. non-condensing, 1250 lb., 925 deg. F. turbine will be installed at Logan Station to drive a hydrogen cooled generator. Another industrial station now under construction is of interest because of its unique construction and design, even though operating at the comparatively low pressure and temperature of 275 lb., 200 deg. F. superheat. This is the Olsen Rug Co., where the power plant is being built as an integral part of the factory building with coal bunkers extending to the roof, the coal handling system consisting of a new and very flexible system of conveyors. Back pressure operation of turbines is planned, surplus steam beyond immediate process needs being absorbed in a large water storage tank on the roof.

At least one turbine manufacturer reports a continued tendency in the industrial field toward higher steam pressures and temperatures and more complex turbines having one or two points of automatic extraction with a definite demand for finer speed and pressure regulation at extraction points.

Electrical Features *of the* Plant Today

If the marvelous development in the steam generating side of the power plant described in the foregoing is far beyond anything the early pioneers in steam development dared imagine, the development of the electrical end is no less so. Edison, with all his foresight and imagination, could scarcely have imagined the extent to which the industry started by his Pearl Street Station would grow. The "Jumbo" dynamos of Pearl Street Station bear as little resemblance to the great turbo-generators of today as did James Watt's steam engine.

The electrical industry and the steam power plant have grown side by side; each is dependent upon the other. Boilers of 1,200,000 lb. of steam per hr. capacity and turbines of 60,000, 100,000 and 160,000 hp. would not exist were it not for the possibility of generating and transmitting power electrically. For, as pointed out in another section of this issue, the two great inventions of historical times were: first, the use of expanding gases as a source of power, and, second, the electrical transmission of power. In the early days of the steam engine, power was used directly. It was transmitted very short distances, mechanically, by belts and shafting, but the limitations of such transmission systems required that the loads—the points where the power was used—be located close to the point of generation. Such transmission systems necessarily were limited in their capacity and as a consequence the amount of power that could be concentrated at any one point was relatively small.

The discovery of the transmission of electric power changed this situation entirely. For the first time in the history of the world it became possible to produce almost any amount of power desired at a strategic location and to transmit that power to any number of places far removed from the point of production. For electrical machines, as is well known to engineers but not to the average non-technical individual, do not create power but serve merely to convert and to transmit power. And in this lies a series of technological facts that socially, as well as technically, will transform today, with its failures and disasters, with a new tomorrow.

The Modern Generator

Unlike some of the equipment in the boiler plant, the electric generator, despite difference in the structural form of units, is a highly standardized machine as regards its principles of operation. In both the direct current generator and the alternator, the fundamental principles are still those discovered by Faraday. The high speed, revolving field synchronous machine has become the accepted standard all over the world for alternating current generation and in direct current work, the slower speed, shunt or compound wound, generator is standard.

The modern high capacity alternator is best exemplified in the new 183,333 kv-a. machine installed at Richmond Station this year. This is the largest single element generator in the world, and while it is unlikely that there will be any need for much larger machines in the near future, larger machines can and will be built if necessary. By the adoption of certain principles of construction and by the use of hydrogen cooling, designers claim that units of 375,000 kv-a. are possible. Principal among these proposed changes is the mounting of one or more synchronous condensers, running free, on top of the generating unit proper. The purpose of this synchronous condenser is to supply all, or a certain amount, of the reactive kv-a. A desirable and economical combination can be obtained by dividing the ratings so that the main generator will be capable of delivering the full kw. rating at 0.9 to 0.95 power factor and the synchronous condenser carry 0.2 to 0.25 of the combined 1.0 kv-a. 0.8 power factor rating. By building such a multiple element generator and using aluminum field coils together with hydrogen cooling, it is said that generating units of 375,000 kv-a. capacity are possible.

The use of hydrogen for cooling generators is probably the next major step or change in generator operation, and though hydrogen cooling has been used with entire success in connection with synchronous condensers during the last few years, it was not until this year that the first hydrogen cooled generator was ordered. This is the 40,000 kw., 3600 r.p.m. non-condensing machine for the Logan Station of the American Gas and Electric Co. One of the obstacles preventing the earlier use of hydrogen as a cooling agent in generators has been the lack of a suitable type of seal around the shaft. In the synchronous condenser this problem does not exist because the entire unit, bearing and all, is encased in a sealed enclosure.

The modern generator is not only the product of long experience in the theory of design but also of materials research. The stator core of the Richmond generator for example is built with the lowest loss silicon sheet steel commercially obtainable. Sheet steel of high silicon content is more susceptible to warping and buckling than steels of lower silicon percentage and as a consequence it has been difficult to build cores on large generators with such steel that are sufficiently tight. In the case of the Richmond machine the engineers of the American Rolling Mill Co. undertook the production of sheet steel of high silicon content that was free from bends.

Generator voltages today have become more or less standard around 13,000 but a number of machines have been built in this country in which 22,000 v. is used, while in England machines of 33,000 v. have been used successfully. The new 80,000 kv-a. Port Washington generator is a 22,000 v. machine. Because of the smaller amount of copper necessary, it is quite probable that there will be a more general tendency to use 22,000 v.

The question of voltage in generator design is important only insofar as it affects the size and, therefore, possibly the capacity of units. With higher voltage less copper is required but at the same time more or better insulation is necessary. As better insulating materials become available, voltages may go higher. With the modern transformer with its efficiencies of 99.5 per cent, generator voltage has little bearing upon transmission voltage insofar as operating economy is concerned. In metropolitan areas where current is transmitted at nearly generator voltage,

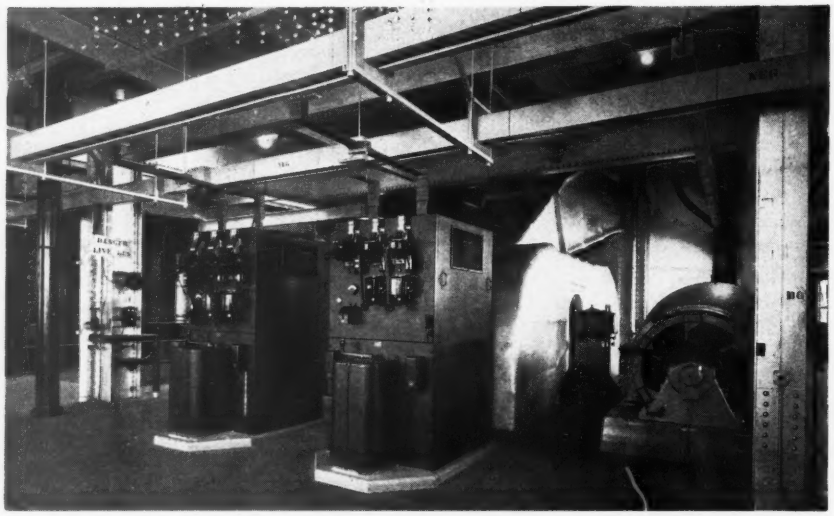


Fig. 1. View of the boiler room of Connors Creek station of Detroit Edison Co., showing the auxiliary bus arrangement and control cubicles for motor driven fans.

however, increases in generator voltage may eliminate investment in transformer equipment.

Excitation practice today favors the use of the shaft driven exciter and for large units, such as the Richmond machine, the use of the pilot, or sub-exciter, has been common. The use of the pilot exciter provides quicker excitation response, an essential requirement in preserving stability on large systems.

It is quite possible, however, that the present day exciter may be displaced in the future by electron tubes. Thus far, no commercial application of the thyratron exciter has been made on generators but with its successful use on a 15,000 kv-a. synchronous condenser at Scranton, its application to generators is quite possible. Thus far the power engineer has regarded the electron tube with some distrust and he has been hesitant to apply it to his power systems, but a few such pioneer installations as that at Scranton will break the barriers and lead to further development in that direction.

The same is true of electronic voltage regulation. Thus far, except in a few small special instances, the electronic voltage regulator has not made its appearance but the voltage regulator can easily be combined with the exciter in the thyratron tube excitation system and future development, undoubtedly, will be in that direction. This implies no criticism of the present day voltage regulator or exciter. These are both highly developed, reliable and efficient equipments and together they accomplish all that is expected of them but the electron tube is so versatile, so marvelously flexible a device that it is inevitable that it will find application in all possible branches of the field. Its inherent characteristics with respect to speed of operation make it extremely useful in applications such as this.

The development of the regenerative cycle for feedwater heating has resulted in an almost entire use of electrically operated auxiliaries in the modern power plant. Before the development of extraction heating it was desirable to use a certain number of steam driven auxiliaries in order to provide sufficient low pressure steam for feedwater heating. Now, practically all auxiliaries are motor driven. As a consequence, the station electrical system has become an important element in the general design of the plant and its arrangement requires considerable thought and study in each case. While 230-440 volts is used for certain of the smaller motors, most auxiliaries, 50 hp. and over, today are driven by 2300 v. motors. Even at this relatively high voltage, the size of conductors necessary to distribute the auxiliary power in large stations become quite formidable and special types of construction have been evolved. At Richmond Station, a single sectionalized metal-clad bus, each section having a separate source of power and serving the auxiliaries for one half of each of the new boilers is provided in the boiler room.

The auxiliary bus construction in the Plant of Today is typified by the installation shown in Fig. 1 which is that at the Connors Creek Station of the Detroit Edison Co. The motors here are direct current units operating at 240 v. and since many of them are of large capacity, an aluminum bus system is installed in the boiler room, running vertically up the boiler room wall to the forced and induced draft fans and coal handling equipment. As can be seen in the photograph, each leg of the bus, positive and negative, consists of two aluminum channels suspended from the ceiling. This photograph also shows the controllers and circuit breaker cubicles for the individual motors.

As at Connors Creek many stations still use direct current motors for those auxiliaries which operate at varied speeds but as alternating current motors with more flexible speed characteristics are developed this practice is giving way to a more general use of a.c. motors. The use of direct current motors has been especially prevalent in the case of stoker drives.

A factor which may change this is the recent development of the so-called thyratron motor. This motor as pointed out in another part of this issue is a motor which operates from the alternating current mains but which has the smooth speed characteristics of the direct current motor. The first commercial application of this motor was made this year in one of the stations of the American Gas and Electric Co. where a 400 hp. unit was applied to a forced draft fan.

In no one part of the electrical system of the power plant has there been more diversity and change dur-

ing the years of the industry's development than in the switching arrangements and bus structure. Starting years ago with the simple group phase arrangement behind a simple vertical panel switchboard, there developed successively, the horizontal isolated phase system, the vertical isolated phase system and finally the metal clad both indoor and outdoor bus arrangements. Opinion as to the relative advantages of these various arrangements is divided and in the past a certain amount of confusion has existed. And even today, the future trend is not clear. This variety of design has characterized not only the bus structure itself but the switching equipment as well. During the past fifteen years great variety of different types of circuit breakers were developed, most of which though quite effective for their purpose, possessed inherent limitations and lacked standardization. It was not until the development of the De-ion theory and the De-ion breaker and the Oil blast breaker several years ago that anything of an orderly nature invaded the field of circuit breaker design. Today, though there still exist a great variety of types and sizes of circuit breakers, the theory behind their operation is much better understood and the equipment available today is of a high order of perfection compared to that which prevailed a decade ago.

Breaking 2,500,000 kv-a. in Three Cycles

The speed of operation has greatly increased and as an example of what is possible in circuit breaker design, attention is directed to the Boulder Dam circuit breakers which have an interrupting capacity of 2,500,000 kv-a. and will break a current of 5000 amp. at 287,000 v. in less than 3 cycles, and do it consistently.

The oil circuit breaker has been an extremely effective device throughout all the years that it has been in use but until recently its design has been more a matter of cut and try rather than scientific knowledge.

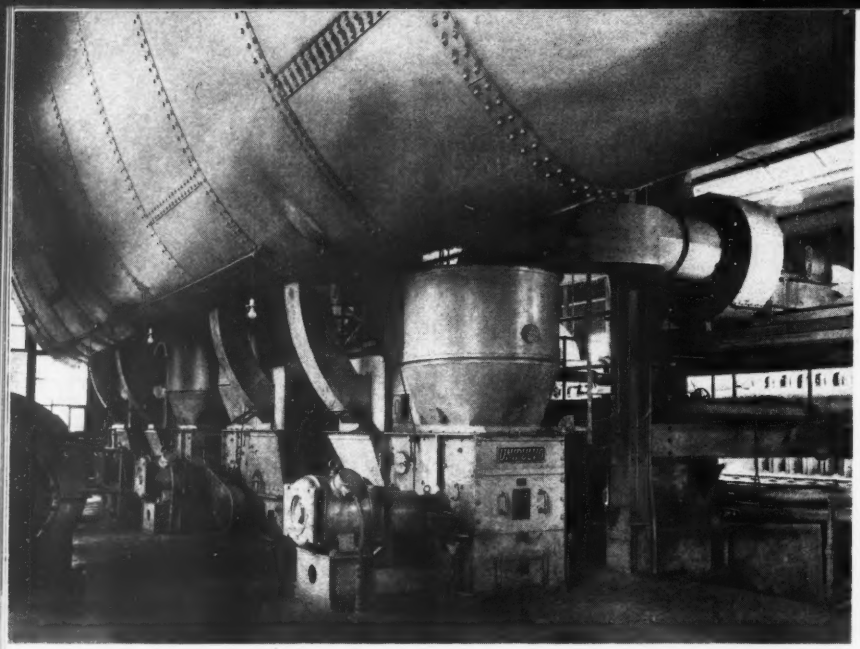
Despite the success of the modern oil circuit breaker, it is by no means assured that circuit breaker development will continue along present lines. It has been demonstrated that with devices of the type of the grid controlled mercury arc rectifier circuits may be interrupted noiselessly and without the slightest electrical disturbance. Just exactly what future developments in this field will be it is impossible to say but in view of the immense possibilities of thermionic devices in the electrical field it would be unwise to assume that present practice necessarily predicts the future course of development.

Where electrical energy is to be transmitted relatively long distances, modern practice in station design is to do away with the low voltage bus in the station and to connect the generators directly to the step up transformers without the use of switches or circuit breakers of any kind. In this case all switching is done on the high voltage side. In metropolitan centers, however, where the energy is delivered to a large number of feeder circuits the generator bus is an essential feature.

While the development in generator design, bus structure and switching equipment has been of enormous importance in bringing the modern plant to the high state of perfection it has today, all of these things are tied in with the element of control. Without electrical control the modern power station or system would be impossible. The control room in the power station today is at once the heart and brain of the whole system—the point from which almost every element of its operation is controlled and governed. Nobody not thoroughly familiar with the details of the present day electrical system can appreciate the marvelous delicacy or accuracy of the instruments which keep the hundreds of thousands of kilowatt-hours produced by the huge generators in leash—how they protect every element of the system, how they measure and balance and check and record milliamperes as well as millions of kilowatts. The subject of electric relaying is so complex, so vast that it cannot be considered here even superficially, but relays are available for every purpose. As an example, recently a relay was required which would operate at zero current in times of trouble and yet it was necessary for this relay to operate in accordance with the condition of the line before the trouble occurred. So a relay was developed which "remembered" the voltage which existed in the circuit before the short circuit developed and operated accordingly even though the voltage was zero at the time its operation commenced. This is typical of what relays can do.

Another example is the re-closing circuit breaker which when a short circuit occurs opens and then immediately or after a suitable time interval, recloses once, twice, or three times if necessary until the fault is cleared or finally if it continues to persist, locks out permanently. This almost human action is, of course, accomplished through the use of relays.

The development of this equipment is so well understood and has reached such a high degree of perfection that it is entirely possible today to build an entirely automatic power plant. From an economic standpoint this might not possess any particular advantage since a certain amount of personnel is desirable in any case. In an instance described in a recent issue of this publication, a small steam turbine plant operated entirely unattended, being remote controlled from a larger plant. Automatic substations and hydro-electric plants have been in operation many years having no more tangible connection with points of human control than a pair of telephone wires. From a purely technical standpoint there is no reason for human supervision in a plant, indeed in the modern plants the attendants have little to do except to check the operation of automatic devices. As a consequence, more and more the control is being centralized at one point and in the case of stations such as Bremo Station this applies not only to the electrical side of the plant but to the steam generating side as well. At Bremo the control of the entire station, boiler and turbine, is centralized in a single control room. The plant of the future will use automatic control devices to an even greater extent than the most completely equipped present day plants. As control devices become more reliable and as we learn to repose greater trust in them, more and more will they displace human supervision and "personnel" will become the scarcest commodity around the plant of "tomorrow."



FUELS

Pulverizers in the Boiler Room of a large Canadian Sugar Refinery. (Photo, courtesy Strong-Scott)

COAL, OIL and gas, all products of nature accumulated through past ages, are still the most important fuels used in the generation of steam. From the very beginning of power plant history, engineers have sought other fuels that are capable of being replaced as rapidly as needed, but only an insignificantly small portion of our present day fuel needs for power requirements can be economically produced in competition with coal, oil and gas. Some day, perhaps, the scarcity of these fuels may force industries to utilize other sources of heat that are now economically prohibitive, but scientists estimate that coal still unmined is sufficient to supply our needs at the present rate for over 6000 yr. so the ultimate solution does not seem urgent to the fuel using public.

Advancements in the utilization of fuel using equipment in power plants, however, have been responsible for the reduction of fuel requirements from an average of 3.2 to 1.45 lb. of coal per kilowatt-hour of electric energy generated in the central station plants of the country, over the period of the last 15 yr. Such an accomplishment is not to be discounted but engineers recognize that much is still to be done in the way of more efficient use of fuels in the average power plants of the country, and it is to this end that research in fuels and their utilization is being intensively directed.

Developments in the Use of Coal

By far the most important fuel for power generation is coal although of recent years oil and gas have been able to compete with coal in favored localities and special plant conditions. Coal, however, is extremely variable in character and has necessitated the development of widely different types of burning equipment. Then too, as the better grades of coal become depleted the problem of undesirable impurities becomes more aggravating and such difficulties as clinkers in the fuel bed, on the side walls of the furnace or on the tubes, and objectionable stack gases arise. So the problem of coal burning is continuously changing, and the methods and means employed must meet these changes as they occur. Likewise, intensive research is being carried on by technical societies, government bureaus and university experiment stations throughout the entire country. A notable aid to engineers wishing to compare available coals is a list of factors which should be considered, compiled by the Joint Committee on Fuel Values of the A.S.M.E. and the A.I.M.E. These are given below:

I. Physical and Chemical Properties.
1. British thermal units (as shipped and as fired).
2. Amount and kind of water-cooling surface in the furnace.
3. Ash per cent.
4. Sulfur per cent.
5. Volatile per cent.
6. Hydrogen.
7. Fusing temperature of the ash.
8. Size.
9. Grindability.
10. Friability.
11. Coking characteristics.
12. Chemical composition of ash.
13. Character of clinker formation.
14. Ignition rate.
15. Uniformity or variability of one or more of above qualities.

II. Plant Characteristics.
a. According to type of coal-burning equipment:
1. Hand-fired.
2. Stoker-fired.
3. Pulverized coal.

There are numerous variations in detail in the equipment available, under each of these broad classifications, and in addition, any two plants, though identical in coal-burning equipment, may vary in one or more of the following:

b. 1. Size and/or shape of furnace.
2. Amount and kind of water-cooling surface in the furnace.
3. Available draft.
4. Amount of heating surface exposed to radiant heat.
5. Maximum load.
6. Duration of maximum load.
7. Character of load.
8. Coal handling and storage facilities and requirements.
9. Spare units available.
10. Competence and adaptability of boiler-room personnel.

The variables above, (b), will affect furnace or fuel bed conditions, by determining:

1. Rate of fuel feed.
2. Temperature of fuel bed.
3. Temperature of furnace.
4. Length of flame travel.
5. Heat release. (B.t.u. per cu. ft. furnace volume per hour).

Depending upon the particular combination of these factors in a given plant, coal qualities may limit (a) efficiency, (b) operating cost, and (c) capacity, as follows:

III. Efficiency
a. Coal qualities may limit the efficiency of a given plant by their effect on:
1. Loss of unburned solid fuel in the ashpit, or carried off through the boiler.
2. Distribution of air in the fuel bed, directly affecting the percentage of carbon monoxide and carbon dioxide in the flue gases.
3. Loss due to hydrogen and moisture.
4. Loss by fouling of heating surfaces.

b. Operating cost.
The effect of coal qualities on operating cost will vary among plants, according to:
1. Method and cost of coal and ash handling, including maintenance of coal and ash-handling equipment.
2. Labor wage scale, and relative amount of labor required per unit of steam output.
3. Maintenance of:
a. Grates.
b. Furnace.

For The Power Plant

c. Pulverizers and burners.
d. Fans.

c. Capacity.
Coal qualities may affect the capacity of the plant by their variation in:
1. Clinkering.
2. Character of the fuel bed.
3. Rate of ignition.
4. Grindability.
5. Fouling of heating surfaces.
6. Any efficiency limitation, or deficiency in B.t.u., that requires the handling or preparation of qualities of coal and/or ash in excess of the capacity of handling equipment.

Other reports of investigations have come through the A.S.T.M. dealing with tests to determine the grindability of coals, one method employing a ball mill on a laboratory sample, the other determines the relative grindability by comparison with a standard sample, the energy required in each case being a measure of the grindability.

There is an increasing demand noted for prepared coals, coals that have been sized, screened, washed or otherwise treated to reduce ash content, lessen clinkers and raise the efficiency of combustion. Such coals are particularly desirable in cities where smoke ordinances are rigidly enforced.

One of the latest developments in fuels is the production of solid smokeless fuel by the carbonization of Utah and Wyoming coals. It is reported that the products of this carbonization consist of various percentages of gasoline, kerosene, fuel oil, creylic acid and a semi-coke which compares favorably in ignitibility and burning properties with semi-cokes produced with raw coal, metallurgical coke, petroleum coke, cannel coke and anthracite.

Iowa Coals Burned on Underfeed Stokers

Many reports have come in from all parts of the country which indicate that the combustion problem is better understood today by operators than in years past. For instance, the burning of Iowa coals on underfeed stokers has been considered next to impossible by many, but very satisfactory results have recently been secured. In another plant buckwheat No. 4 which is a small size anthracite new in the field, passing through a round mesh screen 3/32 in. in diameter, is being used with satisfaction on forced draft traveling grate stokers with zone control of air distribution. The fuel delivery is unusual here as it is mixed with water at the central breaker and pumped to the steam plant through 1000 ft. of 8-in. pipe. The coal is dewatered by means of screens at the plant then distributed to the bunkers by a flight conveyor. This fuel has been found admirably suited for uniform steady loads where the combustion rate is around 25 to 30 lb. per sq. ft. of grate surface.

Such investigations as were carried out at the Bureau of Mines on underfeed combustion as affected by fuel size and air temperature, and the studies made by Dillon and Engle on the economics of preheated air for stokers are unquestionably aiding in a better understanding of combustion problems.

Storing of coal in silos seems to be a growing practice particularly at plants where real estate values are high or where the dust nuisance must be eliminated. To aid operators in the handling of coal stored in silos or similar storage space, bin level indicators have been developed. In some cases control devices stop the operation of the coal elevator when the bin has been filled and give alarm when the bin level has dropped to a predetermined point.

During the year some improvements in the details of coal conveying equipment have been noted such as an improved motor driven grab bucket and a self-alining belt conveyor idler. The most radical development is a runaround conveyor which operates on the Redler principle but does not elevate; the coal may be conveyed in several directions, around horizontal curves, discharged at any point and the surplus returned back to the feed point for recirculation. A feature noted in recently built power plants is the provision made for handling coal and ash without allowing dust to fly about the equipment. Closed chutes and bins have been a big help and vacuum and hydraulic conveying are resorted to in many instances.

A development destined to have a far reaching effect on stoker design and application is the water cooling as applied to the tuyeres and over-feed section of underfeed stokers developed at the Cedar Rapids, Iowa, plant of the Iowa Electric Railway & Light Co. The results of this cooling are given in considerable detail in the report of the A.S.M.E. meeting later in this issue. Low grade strip mine coal with an ash fusing temperature of around 1900 deg. F. which could not be burned with preheated air on stokers of the type designed 15 yr. ago is now being burned successfully at rates of from 40 to 50 lb. fuel per sq. ft.

Outside of this stoker developments in the power field have been confined to details such as more flexible and reliable driving equipment, more convenient and efficient grate clips for traveling grate stokers. It is noteworthy that the completely automatic stokers of the types used for household furnaces are being built in larger sizes with capacities to serve 500-hp. boilers. This brings them into the field of many industrial plants. With the larger sizes, such features as

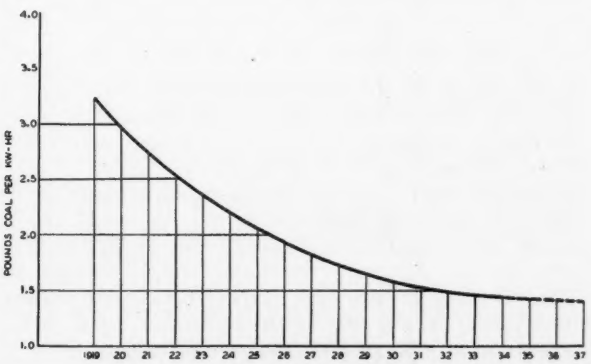


Fig. 1. Average pounds of coal used per kilowatt-hour in all central stations in the United States

air control and ash removal have been highly developed.

Coal Burning Equipment Sales Increase

Government statistics for the past three years show that the sale of stokers in all classes has gradually increased each year with the smaller stokers far in the lead as to number. In large commercial and high pressure steam plants of capacities over 300 lb. of coal per hour the number of stokers installed under fire-tube boilers up to November 1, the latest figures available at the time of this writing, was 1425, under

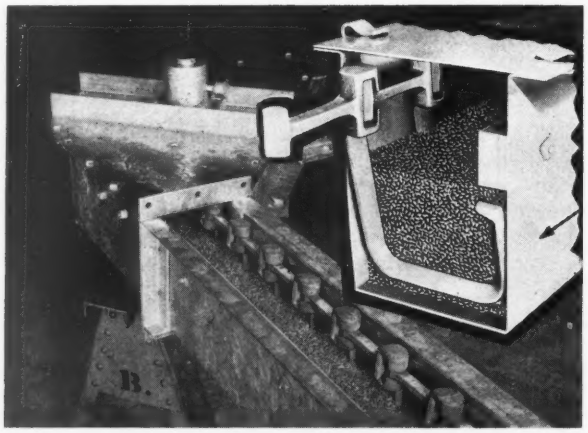


Fig. 2. Runaround conveyor employing Redler principles

water-tube boilers the number was 479, the boiler horsepower capacities, however, were respectively 186,085 and 180,116.

Between the two systems of preparing and firing pulverized fuel, the popularity of the direct fired or unit system is crowding the storage system almost completely out of the field up to November 1, the latest figures for the year. The capacity in pounds per hour for the unit systems sold was 834,950 and for the storage system, 7360. Compared with former years, pulverized fuel equipment sales are showing rapid advancement in the last month. This may be due to the fact that large utility plants are planning extensions to take care of increasing loads. The preference of fuel burning equipment for small boilers seems to be stokers. Considerable progress is being made, however, in adapting pulverized fuel for smaller boilers in the range from 100 to 500 hp.

Burners Permit Quick Change of Fuel

In the power field fuel competition is very strong. Coal, oil and gas are offered in some markets at prices so nearly comparable that slight changes may throw the advantage one way or the other within a short period of time. To meet this condition manufacturers have developed burners that permit the use of any or all of these fuels either separately or all at the same time in any desired proportion. Quick changes are thus possible to meet the market conditions without interfering in any way with the continuity of boiler operation or changing the furnace refractory arrangement as is necessary with most stoker installations.

Quite a number of improvements have been made in the details of pulverized coal equipment such as more flexible driving means for pulverizers, electrical interlock systems and bin level indicators. Announcement has been made of a new type of pulverizing mill employing a bowl as the pulverizing element. The power required to drive this mill is reported to be almost directly proportional to the load.

What may be termed a two-stage burner has been developed abroad for use with Lancashire boilers. The pregasifying chamber communicates directly with the boiler flue, so that the combustible gaseous products which are formed pass to the boiler flue itself, where they become mixed with the secondary air necessary for complete combustion. The quantity of air supplied with the fuel, as it enters the pregasifying chamber, is definitely limited to amount required for gasification.

Air polution, a term which includes the emission of black smoke, fly ash and obnoxious gases, is still without a complete solution so far as power plants are concerned. Black smoke can be eliminated and is in most cases where the proper kind of fuel is burned in well designed furnaces under the care of well informed operators. Fly ash, however, is not so easy to eradicate although considerable progress has been made by the employment of such means as cinder catchers, flue gas washers and electrostatic precipitators, all of which are being more commonly used. Sulfurous gases offer a problem that has been baffling chemists for years but no satisfactory and economical solution has been devised. An unfortunate phase of this situation is that as the coal supply of the country decreases and inferior grades must be used, these will undoubtedly contain a higher percentage of sulfur than those in common use today.

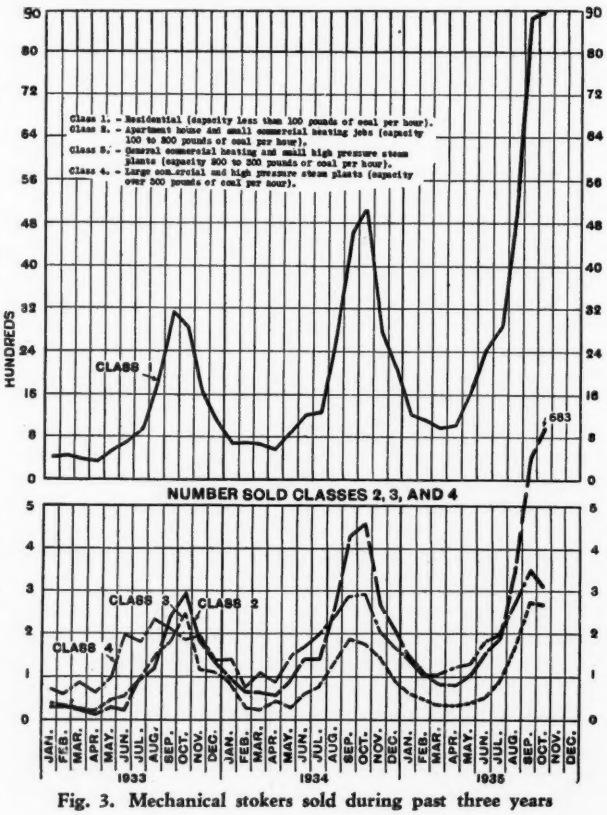

HUNDREDS
Class 1. - Residential (capacity less than 100 pounds of coal per hour).
Class 2. - Apartment house and small commercial heating jobs (capacity 100 to 300 pounds of coal per hour).
Class 3. - General commercial heating and small high pressure steam plants (capacity 300 to 500 pounds of coal per hour).
Class 4. - Large commercial and high pressure steam plants (capacity over 500 pounds of coal per hour).
CLASS 1
683
NUMBER SOLD CLASSES 2, 3, AND 4
CLASS 3
CLASS 2
CLASS 4
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1933
1934
1935

Fig. 3. Mechanical stokers sold during past three years

Each year finds more plants turning to oil as their steam generating fuel. This past year has been no exception. There are many reasons for its popularity with comparative cost its principal drawback. Oil, however, is not a foolproof fuel, i.e., it must be used properly or combustion difficulties and inefficiency will result from its use. Recognizing this, fuel engineers have given considerable thought to the problem of burning oil, research work has been carried on to determine best methods of atomizing, proper temperatures for various viscosities of oils, furnace requirements, control methods, distribution of heating surfaces to secure the desired superheat and combustion air requirements. This data has now become fairly well established with the result that an operator following instructions carefully will have little difficulty in keeping up steam in an oil-fired boiler. There are, however, a number of oils used for steam generation that are products of refineries each one of which has individual characteristics and as a rule the method of burning must be worked out for each product.

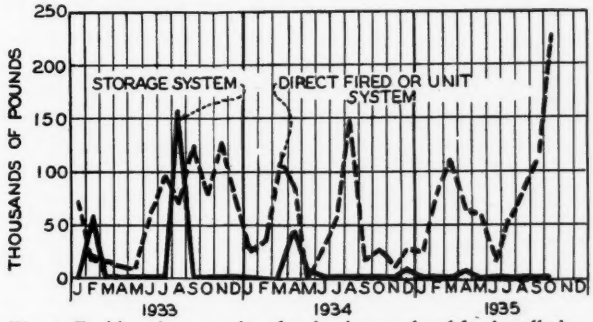

THOUSANDS OF POUNDS
250
200
150
100
50
0
STORAGE SYSTEM
DIRECT FIRED OR UNIT SYSTEM
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1933
1934
1935

Fig. 4. Fuel burning capacity of pulverizers ordered for installation under steam boilers

Cracked residue is one of those for which the essentials for efficient combustion formulated by M. J. Hanlon of the Black Diamond Steamship Corp., are as follows:

(1) Provide correct preheating based on the viscosity of the fuel oil.

(2) Maintain a high furnace temperature.

(3) Adjust for long flame travel.

(4) Complete flame propagation in two-thirds the length of the furnace.

(5) Adjust air regulation to provide the requisite quantity by weight per pound of fuel oil being consumed.

(6) Keep excess air admitted to the furnace at a minimum as it is a waste of fuel to heat the excess air. Fuel is the sole source of heat and costs money.

(7) As an additional precaution against slagging, treat the furnace refractory linings frequently with a coating of high-temperature cement.

(8) Maintain fireside surfaces of boiler tubes in a clean condition.

(9) Guard against outside air leaks through boiler casings.

(10) Check stack temperatures.

(11) Analyze flue gases as a check against excess air, and to correct air regulation.

(12) Maintain oil preheaters, air heaters, suction strainers, discharge strainers, fuel-oil lines, burner tubes, and atomizers in a clean and efficient condition. Provide air turbulence.

(13) Do not allow furnace carbon to build up in mass formation.

(14) Do not allow flame impingement on carbon formations of furnace linings—this will result in the production of smoke and inefficient combustion.

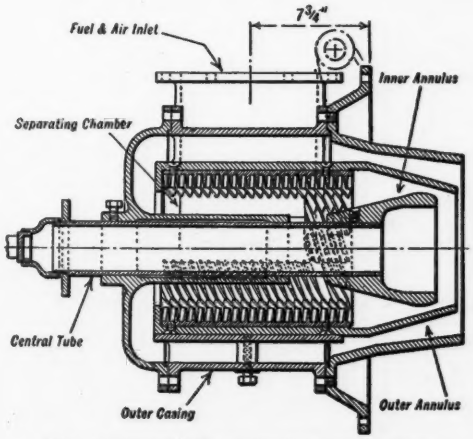


Fig. 5. Pregasifying pulverized coal burner

Some improvements in the details of oil burner design have been noted but as a rule this equipment has become well standardized. The advantages, however, of having a furnace equipped to burn oil, gas or pulverized coal with little or no change in equipment has brought about the development of several burners capable of using two or more fuels and these are being installed extensively in modernized and new plants.

In the Chicago and Mississippi Valley area the price of gas pumped from the Texas and Oklahoma fields was cut to a low figure during the summer months in order to keep up volume consumption during the non-heating months and this move on the part of the gas companies made gas an attractive fuel to many plants equipped with burners and furnaces adapted for its use. Gas fired steam plants as a rule are high in economy, reports being made from California plants claiming 13,125 B.t.u. per kw-hr. at 65 per cent load factor. As an aid to the control of combustion a fuel flow-air flow meter has been developed and is now on the market. The meter is designed for either oil or gas fuel.

More Power

ELECTRIC POWER used weekly in the United States moved nearer to the 2 billion kilowatt-hour goal when it reached another new peak of 1,983,431,000 kw. hr. during the week ending Dec. 14. This record total represented a gain of 12.2 per cent above a year ago. During the last eight weeks seven new record highs have been established, the exception being the Thanksgiving week.

Power gains over a year ago reported by the major geographical regions were: New England, 10 per cent; middle Atlantic, 7.9; central industrial, 14.8; west central, 10.5; southern states, 14.2; Rocky mountain, 16.2, and Pacific coast, 12.1.

While industry is being forced to take an increasingly greater load as a result of the stepping up of production levels, domestic consumers at the same time have expanded their demands in keeping with the many additions to home appliances.

PROGRESS in steam generating equipment during 1935 shows results of the vast amount of research conducted in recent years. Experimental stages have been passed by equipment for many applications of steam at high pressures and temperatures and new standard designs are being used where special equipment was required in previous years.

Boiler Plants Go Modern

THAT BETTER and more advanced engineering is being practiced generally in the power plants of the country is evident on every side as one observes the recently built or modernized plants throughout the country. Particularly is this trend noticeable in the industrial plants and municipally owned and small utility plants. During recent years, steam generating equipment and boiler room practice have made notable advancements but the benefits of these advancements were confined quite generally to privately owned utility plants and to the large, progressively managed industrial institutions. The year 1935, however, was a period in which the improvements, recently developed, have been incorporated in plant design and from one end of the country to the other advanced engineering ideas are found even in power plants of small size.

Steam Generation, the Center of Research

As the greatest expense in the generation of power by means of steam is the cost of fuel, the boiler room has been the field in which the greatest amount of research and thought have recently been centered. High-pressure and high-temperature steam are no longer mysteries since they have gone beyond the experimental stage and reliable equipment and materials are available in standard equipment.

Pressures ranging from 400 to 1400 lb. per sq. in. have been the standard practice for central station boilers for a number of years. Industrial plants, however, have lagged considerably in the general practice of accepting higher pressures but it is noteworthy that the industrial boiler plants that have been put into operation during recent years have quite generally stepped out of the low-pressure into the high-pressure, high-temperature class. Among these are the 1400-lb. boilers in the plants of the Firestone Tire & Rubber Co. and the Ford Motor Co., while the lower limits in important plants seem to be in the neighborhood of 400 lb. and even institutions like the Annapolis Naval Academy are using 400 lb. pressure.

In the design of water-tube boilers, little change is noted in the arrangement of tubes from the boilers brought out in previous years. Modernization of old plants, however, is forcing designers to a more flexible arrangement of tubes and drums in order to meet space and capacity requirements and the factory built integral boiler and furnace seem to be growing in popularity for such service.

Advances in Boiler Baffling

While not a new problem by any means, boiler baffling has been the subject of considerable thought and research during the past year with beneficial results in many plants where boiler water circulation and heat absorption have been improved by rearrangement of baffling. Modern practice in baffling is shown in the accompanying boiler cross sections. So many operating factors enter into the problem of baffle arrangement that even in the most carefully designed plants a trial arrangement seems necessary before satisfactory results are secured.

Present vogue shows an almost universal use of cross baffling with gases flowing as nearly as possible in an opposite direction to that of the water and steam. Gas velocities are maintained as nearly uniform as possible by proportioning gas areas according to gas volumes as they change with temperatures. Curved baffles have proved an aid in securing this result and filter baffles are being extensively used to control distribution in wide areas. An interesting baffle and superheater arrangement is that installed in the Connors Creek boiler by means of which the degree of superheat at varying loads is controlled through the use of adjustable dampers.

In baffle design care is taken to expose as much of the heating surface to radiant heat of the furnace as possible by placing the first baffle back of the second or third row of tubes. Another precaution is so to arrange the baffles that soot will not accumulate on the

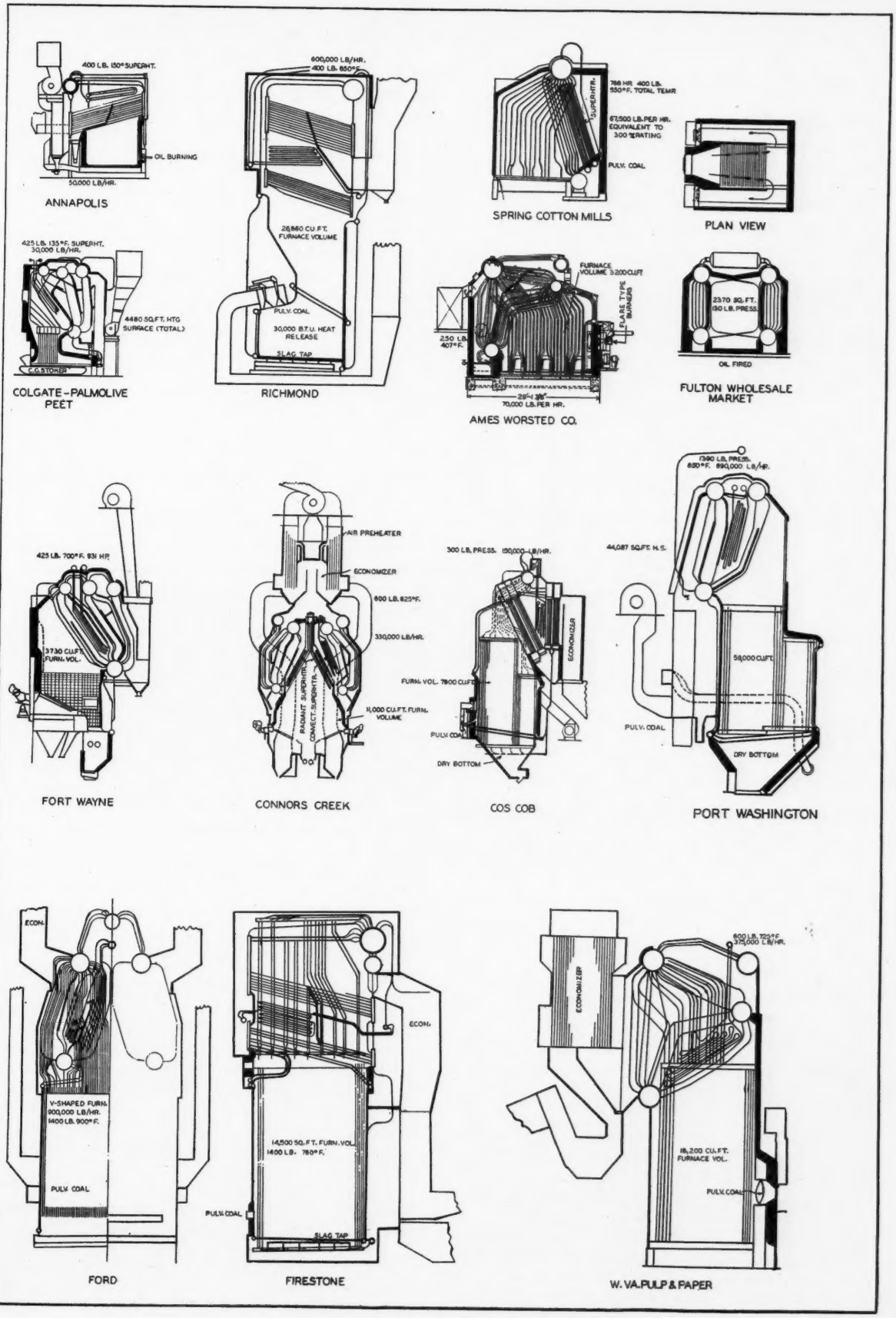
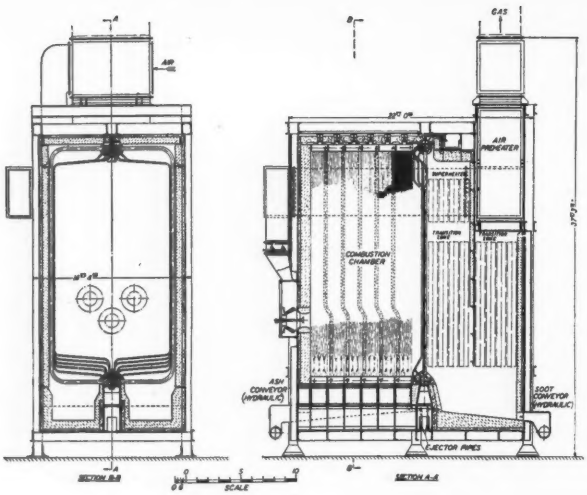
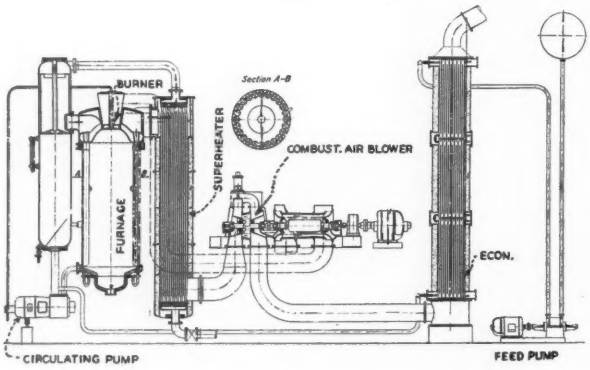


Fig. 1. Cross-sections of typical modern boiler units



A



B

Fig. 2. Recent designs of foreign boilers. A. Benson, B. Velox

metal parts of the shell and tubes as a source of corrosion.

Heat Loss Caused by Soot Expressed as a Percentage of the Heat Made Available by the Burning of the Fuel

Degree of sooting	20-inch boiler Test No.	20-inch boiler Heat loss, per cent	24-inch boiler Test No.	24-inch boiler Heat loss, per cent
Clean	1	0	1 and 2	0
Flight (⅛ inch)	2	3.0	3	1.5
Medium (¼ inch)	3	4.9	4	4.2
Heavy	4	6.4	5	4.2
Do.	5	5.7	6	4.7
Do.	6	5.0	8	5.3
Do.	7	6.6	..	..
Clean	8	0	7	0

As to furnaces, a better understanding of the combustion characteristics of various kinds and grades of fuels has been helpful in securing correct proportions to give complete combustion under the expected variation in load to which the boiler may be subjected. Water walls have weathered the experimental stage of their development and are now used almost universally where high rates of combustion are necessary. These may be either bare or refractory covered, the choice varying with the kind of fuel used and the method of firing, stoker fired furnaces sometimes being designed with both bare and covered water walls.

Where temperatures are not high, air cooled walls are used extensively, the heated air being used for both primary and secondary combustion of the fuel. Solid refractory walls seem limited in present practice to furnaces of low heat release. Research in refractories and refractory materials has been extensive and there has appeared on the market several products of manufacturers that improve the durability, strength and insulating characteristics of refractory products. Some of these take the form of high temperature firebrick and special shapes, others as convenient high temperature cements and still others as high temperature insulating blocks. Likewise, more convenient means have been developed for holding these refractory shapes in arches and walls in place around the furnace, thus also facilitating repairs.

Experience with slag-tap furnaces has progressed satisfactorily in many plants burning pulverized coal. Difficulties encountered with the early designs have now been overcome in most installations and where the coal used has the correct ash fusion temperature many engineers prefer this method of ash removal.

Foreign Boilers

Although many advantages have been shown for a number of advance boiler designs originating in Europe, progress in this country has been slow. The Benson boiler, developed especially for extremely high pressures, is now obtainable through a reliable American manufacturer but as yet no installations have been made here. This is a drumless type boiler and was first used to generate steam at the critical pressure but recent experience indicates that it can be successfully operated at pressures as low as 450 lb. and permits operation of prime movers with constant temperature and variable pressure. Such an arrangement has possibilities for simplifying turbine design and improving efficiency particularly at fractional loads.

Another European boiler which has many possibilities is the Loeffler. Several of these are in use in Czechoslovakia and Russia generating steam at around 1800 lb. per sq. in. pressure and 830 to 900 deg. F. and several other units are now on order for marine and stationary service, but none for use in America. The principle involved is radically different from the conventional American boiler as the boiler proper consists of two superheaters of radiant and convection types, steam being generated in separate evaporating drums by the circulation of superheated steam through water. These boilers are not in themselves self-starting but require an additional boiler of conventional type for starting the generation of steam in the evaporators and for supplying steam to a turbine driving the steam circulating pump. This pump is located between the evaporating drums and superheaters and handles saturated steam.

Experimental work has been continued with the Velox boiler and it is claimed that anticipated results have been substantially obtained. Several installations are now in operation where boilers with capacities as high as 70,000 lb. per hr. are giving satisfactory service at high pressures and temperatures. None of these boilers, however, are in use in America.

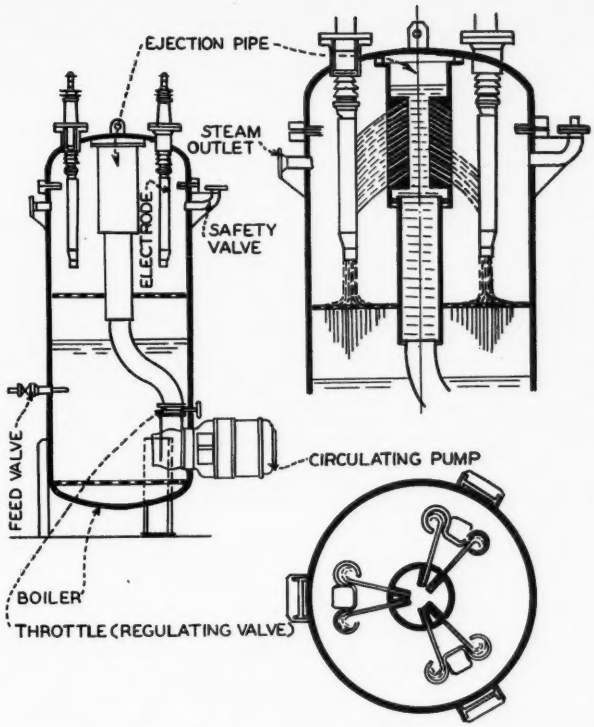


Fig. 3. High voltage electric boilers

No new installations have been made during the past year using mercury vapor in the power generating cycle. Those that are in operation are, however, reported to be giving satisfactory service and mercury vapor cycles are given consideration by the designing engineers of every important fuel using power plant being considered, both utility and industrial. The dyphenyl cycle is also considered but it does not have a background of experience and will undoubtedly have to go through a period of experimentation before it will be accepted by designing engineers.

Electric Boilers

With decreasing electric power rates, many industrial plants that require steam for process work are resorting to the use of electric steam generators due to their simplicity of construction, convenience of operation, small space requirements and ease of control. One Canadian plant reports a saving of 14 cents per 1000 lb. of steam by the use of electricity purchased at a rate of 1 mill per kw-hr. as against coal "at present prices." Such rates, however, are rarely available so that convenience is usually the deciding factor rather than economy. This Canadian installation is of the water resistance type with the electrodes submerged in the water. Heat is generated by the passage of current through the water between the electrodes, the water itself forming the resistance.

In Europe a water-jet type of electric boiler has been developed which uses 3-phase electric current at 2000 v. or above. The current is conducted through a number of water jets which radiate continuously from nozzles to the electrodes. Three electrodes are arranged around a vertical ejection pipe provided with three double rows of nozzles that eject water tangentially on the inner surfaces of the electrodes. From the electrodes the water falls on a perforated plate which is electrically connected with the boiler shell. Circulation is maintained by a pump.

Among the developments of importance in the more conventional types of boilers is an American all welded tubular boiler which is without braces. Such construction has been made feasible through the employment of X-ray equipment for the inspection of welds and a specially shaped dished form of heads. The absence of braces makes the inside of the shell free from obstructions and easily kept clean. It is noted that fusion welding is becoming standard practice for the construction of drums of high-pressure water-tube boilers with several manufacturers.

Application of water walls is revolutionizing industrial as well as central station design and the effectiveness of the modernization program of many old industrial plants depends upon boiler designs which can fit into available head room left after the removal of the H.r.t. boilers. One recent design, covering high capacity per cubic foot of space occupied, consists of a large upper longitudinal drum and a small longitudinal drum placed at about the level of the grates behind the bridge wall. These two drums are connected by tubes as in a two drum vertical boiler. The furnace walls are completely water cooled by tubes which leave the center of the upper drum and curve downward terminating in headers which extend from the front to the rear of the furnace. Tests on one of these boilers rated at 250 hp., fired by a single retort underfeed stoker at the plant of Edward F. Hurff at Swedesboro, N. J., showed an overall efficiency of 82.63 per cent for the boiler and stoker when burning central Pennsylvania bituminous. The average equivalent evaporation is 17,519 lb. per hr., corresponding to a rating of a little over 200 per cent.

In England a wet-back type boiler has been developed called the horizontal Thermax boiler which permits complete insulation of the hot surfaces that never exceed that of the steam generated. The produucts of combustion pass through the boiler flue to the combustion chamber, thence through a bank of tubes to the smokebox at the front, returning at the rear of the boiler through another set of tubes. This arrangement avoids to a considerable extent the passage of the coolest gases through the hottest section of the water space.

Research to Improve Operation

One of the most interesting studies conducted was the research carried on in Detroit with various methods

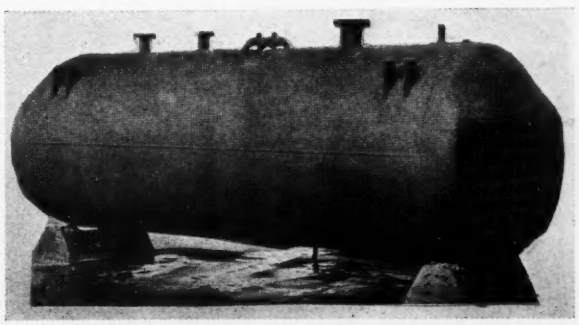


Fig. 4. All welded return-tubular boiler. (Photo, courtesy Henry Vogt Mach. Co.)

of rolling-in boiler tubes and the development of a new method known as the elongation method. When a tube is rolled in or expanded the operation may be divided into two phases, first, the process of expanding the tube until it fills the tube-sheet hole, second, in which the metal is squeezed between the expanding tool and the surface of the tube-sheet hole and is forced to flow axially, and this flow, indicated on a dial gage, is used as a guide to the proper amount of rolling-in.

The effect of soot on boiler heat transmission was made the subject of an investigation carried on at the Pittsburgh Experiment Station of the U. S. Bureau of Mines and the results were reported in per cent of heat

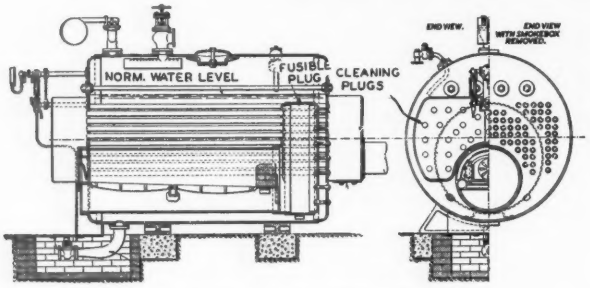


Fig. 5. Cross-section of Thermax boiler

loss as shown in the tube. Although these experiments were performed on small heating boilers at low rates of combustion it is the opinion of those who conducted the investigations that until further tests are made these values can be accepted as applying to other types of heating boilers.

More extensive use of alloy steels has been noted this year than previously. Chromemolybdenum and chrome-nickel seem to be favored steels for parts subjected to extreme temperatures and pressures. Operators, however, find need for more data on the qualities of steels used in boilers since some of these show qualities that give trouble in carrying out repair work.

Operators of power plants recognize water treatment as an individual plant problem, in many cases the treatment must admit of being changed from hour to hour. For this reason it has become common practice in well operated plants to analyze both feedwater and boiler water at intervals best suited to the plant. This practice has brought about the development of rapid and convenient testing equipment by manufacturers specializing in water treatment. During the past year announcements have been made of the availability of colorimetric testing kits for rapid determination of the presence and concentration in water of oxygen or pH, silica and phosphate. Another test outfit makes easy the matching of test samples with color standards in the determination of the amount of phosphate in boiler water. Still another new device is a compensating hydrometer for determining the density of boiler water at any temperature through the employment of a temperature correction scale. A thin metal scale ensures high sensitivity.

Water treating methods have not changed in fundamental principles during the past year but research in this field is being actively pursued by a number of industrial concerns and some noteworthy developments may be announced before long. In England, however, a new colloidal treatment of boiler feedwater has been announced in which pyrogallol is used to absorb the free oxygen in the water.

Feedwater investigations have, however, placed information in the hands of operating engineers that has been of inestimable value to them in not only keeping their boilers free of scale of all kinds but in inhibiting corrosion and embrittlement, and preventing foaming, priming and carry over of precipitates to superheaters and steam using equipment. It is noted that nearly all new plants employ deaerating feedwater heaters for the removal of free oxygen in the fight against corrosion of boilers. Study, however, has been given to the deaeration of feedwater by chemical means and the results secured give promise of its more extensive use. Likewise, the inhibition of embrittlement has been the subject of considerable research of a critical nature but controversy still exists among chemists as to the best treatment and occasional instances of embrittlement are reported by operating engineers.

In spite of everything that is known, the accumulation of scale in boilers is still a bothersome problem

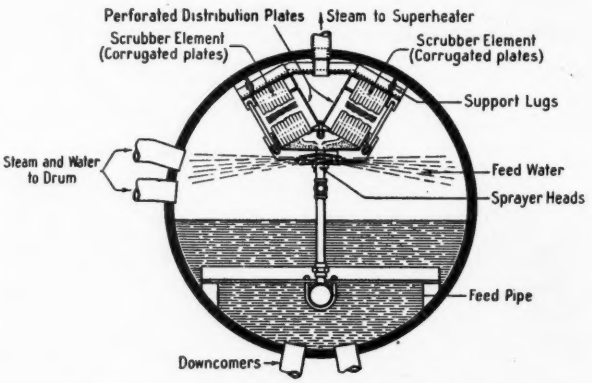
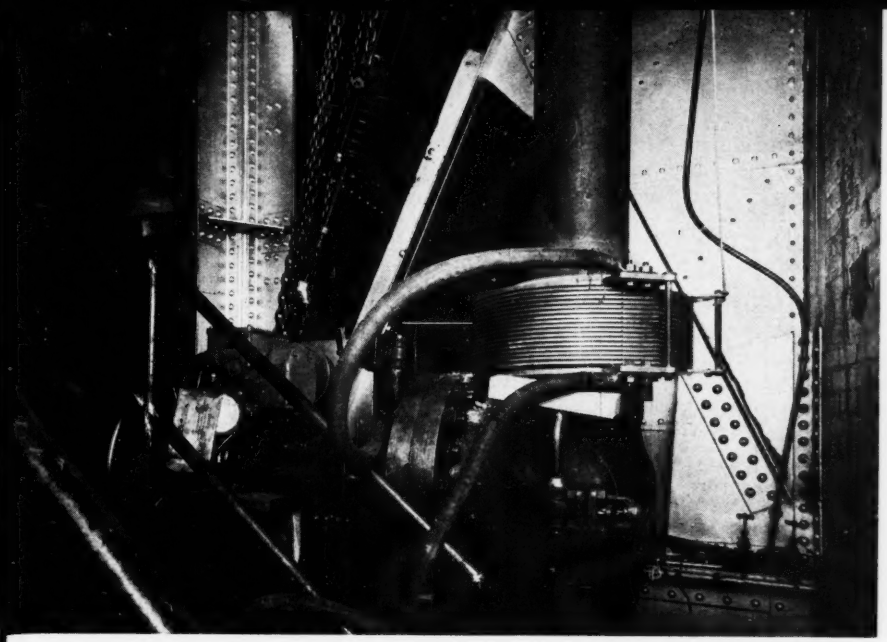


Fig. 6. Steam scrubber employing spray and plates

and engineers resort to the use of tube cleaners to make sure that their boilers are perfectly clean before putting them back into service after a shutdown for cleaning, inspection or repair, so we find manufacturers of tube cleaners continually coming out with new designs that are more convenient, efficient and better adapted to modern boiler plant practice several of which have made their appearance during the past year.

Another operating problem that has been annoying to engineers since the advent of tall boilers is the inconvenience of observing the water level by means of the conventional type of gage glass. In answer to this problem one manufacturer has developed an indicator using mercury in a tube located in the most convenient spot for the operator and is reported to meet the requirements satisfactorily.

Washing steam to prevent carryover of solid particles in to the superheaters and turbines is practiced in a number of plants. Scrubber type steam drum baffles and plate type separators employing two sets of corrugated plates in series have been in satisfactory use for some time, of more recent development is the screen type scrubber which has given excellent results in a number of installations reported. The latest development along this line is shown in Fig. 6.



Electric stress relieving coil on welded joint of 10 in. main superheated steam line at Connors Creek station, Detroit Edison Co.

Piping Follows Advancements In Metallurgy

AS ONE views the field of piping, as applied to power plant practice, for trends in development, there is only one phase that stands out big, and that is welding. Pipe welding is not new to the field, but this almost universal practice has brought about so many changes in pipe fabrication and accessories that are still in the course of development that one is tempted to call pipe welding a revolutionary development the full import of which is not yet realized.

With more scientific data on iron, steel and other metals generally classified as ferrous alloys which have been developed through research, engineers have a wider range of materials from which to choose in the solution of their piping problems. Corrosion, high temperatures and high pressures are still the controlling factors in the selection of piping materials, although in some cases fabricating methods play a part, in all cases, however, comparative prices must be considered because the material which may theoretically best answer the purpose, may be prohibitive from an economic viewpoint.

Features of Central Station Piping

As an example of modern practice in public utilities, Richmond Station is well in advance. Here the piping is of welded construction, wherever feasible, all steel gate, globe and blowoff valves being welded in the line. The main steam piping from the superheater outlets to the turbine connection contains only two flanged joints, those at the turbine inlets. Steam mains up to and including 20-in. size are made of Grade B seamless steel pipe. The 24-in. mains are of rolled steel plate construction with longitudinal welded seams. The carbon content of all pipe was limited to 0.30 per cent to facilitate field welding. All shop and field welding on steam and boiler feed piping was performed by certified welders. All welded joints are of butt-welded construction without reinforcing straps and were made by the electric fusion method. Welds in the high-pressure steam and boiler-feed lines were stress-relieved by heating with electric resistance coils to a temperature of 1200 deg. F.

Valves in the high-pressure, high-temperature steam lines have chrome molybdenum bodies and bonnets, also alloy seat rings and steel discs faced with copper-nickel alloy and nickel steel stems. They are designed for 600 lb. working pressure. Boiler-feed valves are of carbon steel with stainless-steel seats, monel-faced discs, and stainless-steel stems. Small valves for high-pressure steam and drain lines are of forged steel with bolted glands and bolted bonnets and stainless-steel seats and discs.

At Conners Creek, fusion welding by the direct-current metallic arc process was widely used for steam piping operating at full boiler pressure and temperature, 650 lb. and 850 deg. F., and for the boiler feed piping systems operating at 1000 lb. and 385 deg. F. The main superheated steam piping uses no flanged joints between the superheater header and the turbine stop valve inlet; all valves between are of the welded-end type. The type of joint used is shown in Fig. 1 in which it will be noted that an inner chill ring is used to prevent the formation of welding icicles within the pipe. This joint was decided upon only after a great amount of investigation was made using 16-in., grade B, Schedule 80 (A.S.A. tentative standard) seamless steel, containing 0.33 per cent carbon, 0.75 per cent

manganese, 0.06 per cent silicon, 0.04 per cent aluminum, 0.06 per cent chromium, 0.01 per cent phosphorus and 0.02 per cent sulphur. Welds were stress relieved by heating a circumferential band containing the weld to a temperature of 1100 deg. F., holding to that temperature for one hour and cooling in chill air. This heating was done by induction, the heating equipment being shown in the headpiece and Fig. 2.

With the growing use of welding as the approved method of pipe fabrication has come the development by manufacturers of all kinds of equipment used in this art. Several arc welding and cutting sets have been announced during the year, some stationary, some portable, motor or engine drive, for alternating

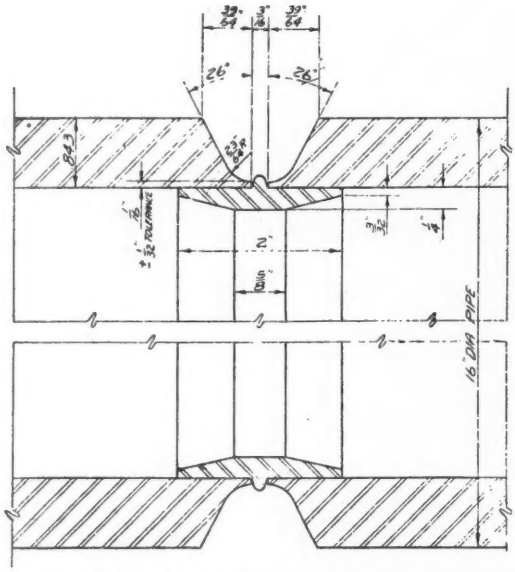


Fig. 1. Type of fusion welded joint used at Connors Creek

or direct current, in capacities up to 200 amp. As a predominating factor in the success of a weld depends upon the welding metal, this has been the subject of considerable research by metallurgists with the result that many electrodes have been announced, each applicable to a specific welding job.

In America, the recent development of welding equipment has been confined to electric type, it is noted, however, that in England a new form of gas has been applied with success. In this process impregnated coal gas takes the place of acetylene. In a typical installation the coal gas is delivered to a small electrically driven compressor which raises the pressure in the line to about 5 lb. per sq. in. After passing through a cleaner, the impregnating liquid is introduced by means of a spray. The composition of the impregnating liquid has not been revealed but it is stated that it lowers the ignition point, and retards the propagation of the flame, resulting in an increase in cutting value and speed of cut, and also that the cut is narrowed and the edges are not hardened.

Advancements have also been made in the construction of steam conduits, making them more convenient to lay and keep in service, better insulated and water proof.

Although pipe welding replaces screwed and flanged joints in many applications, this trend has acted as a spur to many manufacturers of fittings and piping tools to improve their products and it is noted that new gasket materials and designs are coming on the market, also new bolted flanged connections, pipe joints and joint cements. Several pipe threading and cutting tools have been redesigned to make them more speedy, efficient and accurate in their work, as well as extending their scope of application. Pipe hangers have also come in for some improvement, and pipe insulation for specific application is better understood.

Many Valves Redesigned

A review of the progress made in valves would indicate that nearly every valve manufacturer has redesigned many lines of his product, fitting them for every class of service known to industry. The use of new alloys for specific service in the valves is particularly noted. Each part—seats, discs, stems, body—has undergone critical research, tests and service to determine the most suitable material from which it should be made. It is also found that new designs are making valves more convenient to keep in first class condition, some with devices to indicate the amount of valve opening, others with identifying devices, but of particular importance is the trend in design toward valves offering less resistance to the passage of the fluid.

For measuring the flow of fluids through piping, orifice plates have long been used, the range of capacity over which a given size orifice may be used with accuracy is quite limited and to change orifice plates has, in the past, necessitated considerable inconvenience which has now been eliminated by the development of fittings designed especially for this purpose, and in one case the orifice is automatically adjusted to the changes in the rate of flow through the pipe.

Among other developments in equipment closely

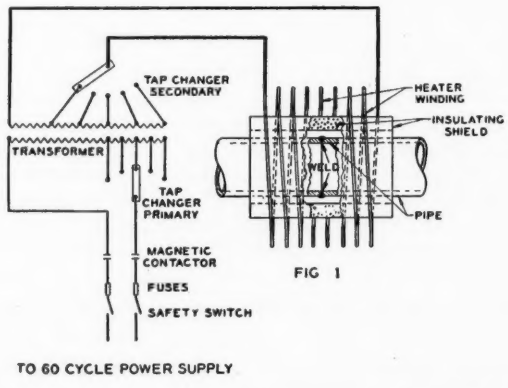


Fig. 2. Arrangement of equipment for stress-relieving welded joint by induction heating method

associated with piping as used in power plants, are noteworthy improvements in the designs and materials used in the construction of strainers for oil, water, air and steam, also quite radical changes in steam trap designs.

Lubrication *and* Lubrication Methods Improving *with* Research

Non-inflammable Lubricants, Turbine oils that remain neutral in service and oil purifying methods are outstanding developments of the year.

FRICTION is the thief of power and since it cannot be completely eliminated engineers have resorted to the use of lubricants to reduce it as far as is humanly possible. In this process of elimination, both bearings and lubricants have undergone vast improvements but research along this line has been continuous since the beginning of mechanical power application and seems to grow more intense as time goes on with its discovery of new materials used for bearings and lubricants and new conditions under which bearings are required to serve. A case in point is the report by the Department of Scientific and Industrial Research of Great Britain of a study of the boundary lubricating value of mineral oils of different origin. This report deals with the conditions such as exist just before the seizing of moving parts takes place. These conditions, described as boundary, become important when starting or stopping the engine.

By experimental evidence it was shown that a solid surface can produce considerable modification in the properties of a layer of liquid in contact with it. For instance, it can selectively pick out certain constituents from a mixture such as oil and concentrate them in a surface layer. Hence, the properties of this layer—for example, the effect of heat upon it—may be quite different from the properties of the oil in bulk. Experiment indicated that with close contact of bearing surfaces a rise in temperature of the oil of, say, 32 to 54 deg. F. may be accompanied by a considerable amount of chemical activity in the boundary area.

It was also shown that wax, the presence of which in an oil is generally regarded as detrimental, as far as fluid lubrication is concerned, may in certain cases exert a beneficial effect when boundary conditions arise.

Acid Formed in Motor Oils

Another investigation carried on in Germany with used motor oils went thoroughly into a study of the occurrence of nitric acid and nitro-compounds in an internal combustion motor. The explanation for these impurities which were found to exist was that in the course of the combustion of the fuel oil mixed with air under pressure in the engine cylinder a part of the nitrogen of the air is converted into nitrous oxide. This, coming in contact with the oxygen of the air, forms nitrogen dioxide and, if water is present, goes to nitric acid. This investigation shows that lubricating oils used for this service change radically during their use and renewal should be made at frequent intervals as a protection against corrosion of the engine parts.

To the operating engineer such investigations as these are important as they indicate clearly the value of carrying out a regular schedule of lubricating all machinery in the plant. An excellent guide for making up a schedule was presented at the Semi-Annual Meeting of the A.S.M.E. by Virgil M. Palmer and Horace F. Smith as a result of their experience in the plant of the Eastman Kodak Co. This schedule is as follows:

Ball bearings on electric motors, once in six months to once per year.

Ring-oiled bearings, once per month.

Plain bearings, hand lubricated, once per trick to once per day.

Plain bearings, bottle oiler lubricated, once per month to once per two months.

Plain bearings, lubricated by wick-feed cup, once per week to once in two weeks.

Plain bearings, with sight feed cups, once per day to once per week.

Plain bearings, with grease cups, filled once per week to once per month.

Plain bearings, with grease cups, turned down once per day to once per week.

Plain bearings lubricated by grease through compression fittings, three times per week to once per week.

Enclosed gears or speed reducers, attention daily to once per month.

Exposed gears, service once per week to once per month.

Exposed cams, daily to once in three days.

Much confusion exists among users of lubricants as to the classification of oils for various purposes and Werner Lehman suggests that oils be classified under principal names like watch oil, sewing machine oil, bearing oil, engine oil, gear lubricant and greases, each with a few descriptive variations indicating one of the main standard measurements of oil quality, such as viscosity, oiliness, pouring quality, or adhesion. It would then be easy, he thinks, to prepare lubrication tables and instructions and it would lighten the task of the engineers specifying lubricants because selection would be a more intelligent process than at present.

Other phases of lubrication which are undergoing

investigation by scientists are the production of synthetic lubricants, factors for rating the quality of lubricating oils, duration of effectiveness of colloidal-graphite lubrication, oxidation stability of lubricating oils, corrosion of bearing surfaces, permeability of such bearing metals as leaded bronze and babbit by oil and the side flow of oil in bearings, all of which promise data of value to the engineer facing lubrication problems.

Central Station Experiences with Turbine Oils

Operating companies reporting to the Prime Movers Committee of the E.E.I. have in past years complained of serious acid conditions of turbine oils after comparatively short service thus requiring either too frequent replacement or continuous sweetening. One company now reports that with a specially processed lubricating oil the acidity has been kept at less than 0.15 mg. of KOH per g. for a period of more than two years, whereas a regular type light turbine oil formerly used over a similar period rose in acidity to over 3.25.

Another company reports that experience with lubricating oils containing antioxidants, used in four high pressure units, has proved the great value of these oils. All usual tests show essentially the same properties after several years' operation as when new. Sludge formation is practically nil, and no oil cooler has been cleaned in the 125,000 operating hours of the four units. This record is especially significant because more than usual amounts of water contaminated the oil due to the particular design of the machines. The oil has limitations, but none of which detracts seriously from its desirability.

The Philadelphia Electric Co. uses the Funk-DeLaval system of continuous oil purification which has permitted the satisfactory use of ordinary turbine lubricating oil for much longer periods than is usual practice. Oil piping has not had to be taken down for cleaning in the 7 yr. the system has been in use and very little sludge is formed.

Considerable progress has been made in reclaiming or reconditioning used lubricating oils. Particularly noteworthy are statements by the U. S. Bureau of Standards and the Armour Institute of Technology. "The Bureau has analyzed a considerable number of samples of reclaimed crankcase oil and found that many of them show as great excellence in the commonly measured properties as do the so-called new oils. It is believed such oils may be better than new oils." From Armour Institute comes the statement: "We have often examined reclaimed oils which gave practically the same tests as the original new oils. This test tends to show that lubricating oil does not wear out. There is no reason why such reclaimed oil can not be used with satisfaction in any automobile engine."

Indices for Suitability of an Oil

In the modern power plant purification of lubricating oil is recognized as being more economical than running an oil until its characteristics make it imperative to provide a new supply. It is recognized that a high grade oil is a good investment and several good indices are available to indicate suitability of an oil. One of these is viscosity, a high viscosity usually results in high oil discharge temperatures and oxidation. The neutralization number of an oil, meaning the number of milligrams of potassium hydroxide necessary to neutralize the oxide contained in one gram of oil, indicates the acid condition of oil and liability to sludge.

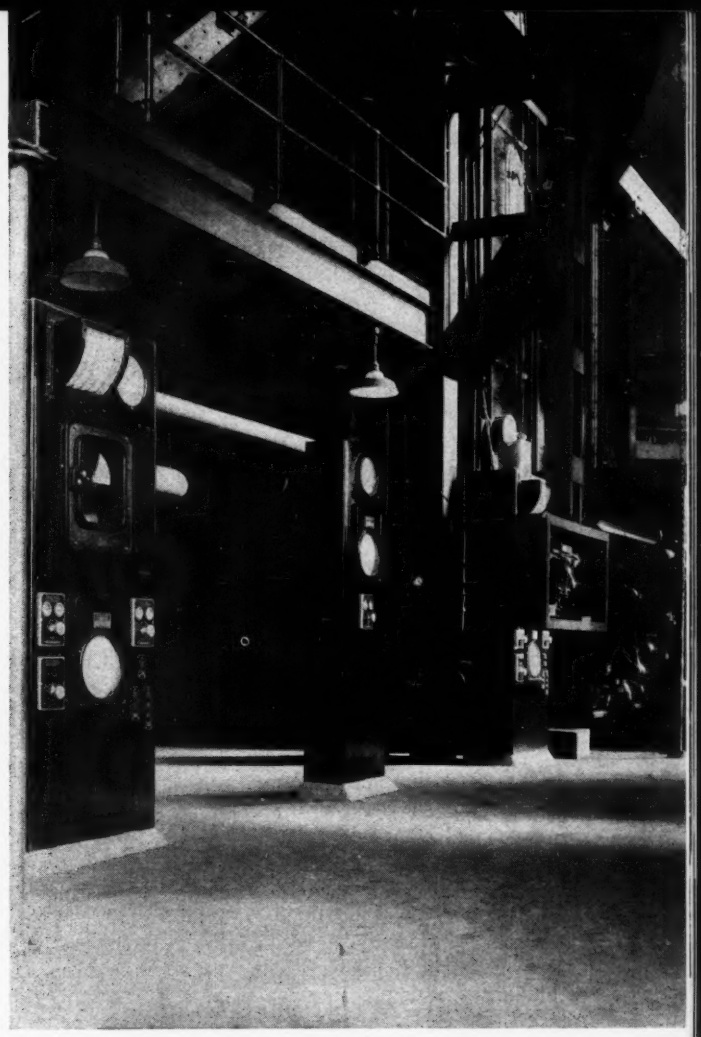
Some oils tend to absorb water more readily than others and form emulsions. Comparison with the emulsion standard will give an index of this characteristic. Also from chemical analysis the amount of carbon residue and sediment indicate at least its initial condition. Centrifuging is the usual method of reconditioning turbine oil as by this means both the heavier insoluble impurities and the water can be removed. Settling and filtering may also be resorted to where large quantities of oil are involved. With a system of continuous centrifuging and periodic batch filtration the arrangement should permit transferring from one tank to another, centrifuging continuously, filling the turbine reservoir, cleaning oil or centrifuging the oil directly from a turbine and then putting it into storage.

Fire hazard has been one of the big problems in steam turbine lubrication and in the design of the Philadelphia turbine, that went into operation during the past year, the lubricating and governing systems were decided upon only after a non-inflammable liquid had been developed. In this unit, oil is used as the lubricating fluid while Aroclor is used for the governing and operating systems. In this way, the operating fluid in the operating mechanisms above the throttle and governing valves does not involve any fire risk. In addition to this provision against fire hazard, steam and motor-driven oil pumps, oil and operating fluid reservoirs and oil coolers are housed in a fire-proof room about 30 ft. distant from the turbine.

The steam turbine driving the auxiliary oil pump is mounted on the turbine room floor, driving the submerged oil pump through a long extension shaft. The motors driving the auxiliary operating fluid and oil pumps are of the totally-enclosed, explosion-proof type, especially designed for use in hazardous locations. Seamless steel piping is used for all oil and operating fluid piping. Flanges are avoided except where necessary to facilitate dismantling, the piping being joined together by butt welds. When used, the flanges are of the welding-neck type welded to the pipe. All nuts or tap bolts are locked with two-bolt plate type washers turned up at the ends.

One manufacturer has developed a bearing which uses micarta in place of babbit or brass. It is reported that with water as lubricant these bearings give a low frictional coefficient at high speeds but water lubricant is hardly practical at speeds below 80 ft. per min. The grease-lubricated micarta bearing, however, is very satisfactory in this lower speed range. It was also found possible to operate micarta bearings for a much longer time after a failure of the grease or oil supply.

Other manufacturers have developed apparatus for the testing of oils for determining their cloudiness, viscosity and aging characteristics. Improvements have also been reported in lubricating methods used on refrigerating equipment, clutches and chain drives, and oil and grease handling equipment. Bearings have also been improved by equipping them with constant-level oilers, protective housings and seals.



Automatic Control is an important feature of the Shelby Municipal Power Plant. The master boiler control panel is shown in the center.

AUTOMATIC CONTROL

CONTROL EQUIPMENT is the nerve system of the power plant and automatic features form the brain that makes the modern power system practical. Try to imagine for a moment operating an interconnected system with a dozen or more generating units in parallel by manual control, a score of lynx-eyed men at throttle and field controls tense with the efforts of their endless task. Don't imagine too long, however, or you will be deluged with complaints from customers or department heads about voltage fluctuations, errors in electric clocks, erratic radios and probably bodily injury from other men trying to keep their machines in parallel. Manual control in these positions would be impossible.

Then try and imagine the tremendous effort and effect on efficiency of operating a complete modern boiler room by manual control. While quite possible, in fact there are plants in the country so operated, the prospect of operating without even a damper regulator would apall an engineer in any but the smallest plant. Even with a full complement of instruments and complete remote control, manual operation would be an exacting task due to the complexity of the modern plant. Like the human eye, control equipment must be guided by the effects produced by changes from normal, and in this sense cannot be considered anticipatory, but instruments can sense and correct these changes from normal before they are perceptible to the eye.

Each piece of equipment that goes into the plant has an inherent characteristic which can sometimes be changed by proper design so as to give a self-contained automatic control. Perhaps the best example of this is the superheater. In the convection superheater the steam temperature drops with load and it is customary to design the elements so as to give the desired maximum temperature at maximum load. At partial loads the temperature is lower thus giving protection so far as excess temperatures are concerned but aggravating the condition of low efficiencies at low loads. With expensive high temperature equipment this represents not only a fuel loss but an economic loss because the incremental cost of the alloy equipment must be justified by but a few hours full load operation.

A radiant reheater, on the other hand, has the opposite characteristic, the temperature increases at partial load and if designed for full temperature at full load, dangerous temperature would be developed at part load and protection would have to be pro-

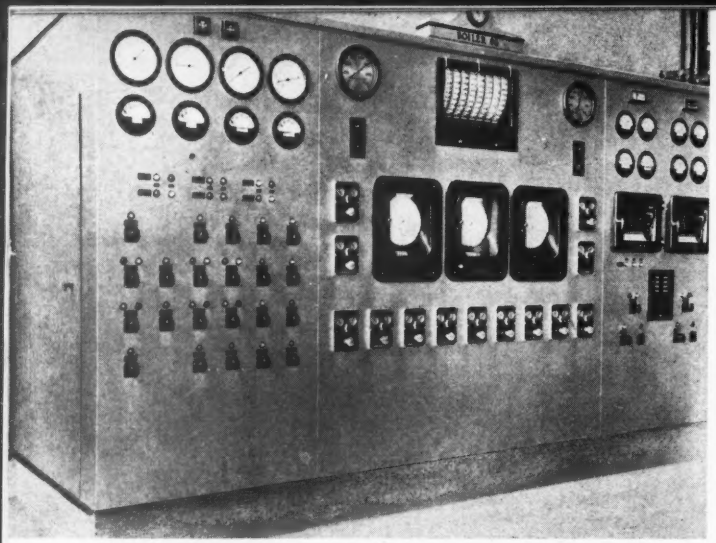


Fig. 1. The boiler panels at Richmond are modern, not only in layout but are the result of a thorough study in visibility and modern lighting. (Photo, courtesy Bailey Meter Co.)

vided by adding a desuperheater. By combining radiant and convection surfaces in the proper proportion an almost flat temperature curve over the useful load range of the boiler is possible. This was done at Port Washington.

Another example of steam temperature control by means of combination radiant and convection superheater surfaces is shown by the drawing of the bent-tube boilers as installed at Connors Creek. The superheater elements installed in the two halves of the boiler are different, one (the left side) consisting of a semi-radiant superheater in the first bank of tubes and on the other side a similar element in the first bank plus a convection element in the second pass. This compensating type superheater arrangement provides a constant steam temperature of 850 deg. plus or minus 5 per cent over the entire operating range.

While limiting the flexibility somewhat, there is no gainsaying the fact that control of this kind should be the logical goal of the industry and if it could be extended to all parts of the plant would justify the elimination of all auxiliary control equipment, no matter how effective. Unfortunately, this is not possible and the modern plant depends on automatic control equipment which centers, with one exception to be mentioned later, around the maintenance of constant or nearly constant steam pressure.

This relieves the turbine governor of the additional responsibility of taking care of fluctuating pressures as well as load changes and increases boiler efficiency and performance. To maintain this pressure constant it is necessary to coördinate the operation of all major and auxiliary equipment. Fuel and air as well as feedwater must be supplied in proportion to the boiler load if efficiency is to be maintained. Fuel supply to the stoker or feeding device is ordinarily left to gravity, coal bunkers or storage tanks being kept at the necessary level by manually operated equipment.

Combustion control is, therefore, the largest major single coördinated problem and automatic combustion control is no longer limited to small simple damper regulators or to elaborate central station systems. Practically all companies have now developed a line of control equipment simple enough and flexible enough to meet the needs of the industrial plant and at a price which makes control economical.

Inasmuch as the details of some of these systems have already been covered and the balance will be covered in subsequent issues, it is not possible to cover them in detail in this issue without duplication. The following report of operating experiences compiled by the Prime Movers Committee of the E.E.I. summarizes the present control situation very well although it must be remembered that this, prepared as the 1935 report, was based on the performance of equipment installed, in some cases for several years, and many of the limitations mentioned have been overcome in newer designs. Although almost uncanny in performance, flexibility and reliability, the combustion control field is not stabilized and practice may be expected to change materially in the future. The report mentioned is as follows:

"Usual application of automatic control is to raw-coal feeders, forced and induced draft fans and dampers. Stoker speed control has been applied in six stations reporting, while two stoker-fired stations have omitted stoker speed control and one stoker-fired station has not stated whether or not stoker speed is controlled.

"Opinion differs as to whether automatic combustion control saves labor when applied to larger plants, one company reporting definitely that there is considerable saving while another reports no saving. One company reports that if all operations now performed largely automatically had to be resumed manually, the additional physical duties imposed on the present operators probably would result in loss of plant efficiency due to inability to adjust equipment continuously as required for best results.

"One company reporting on a stoker fired plant states that the largest factor affecting plant efficiency is automatic control of coal supply. This company states that coal supply manually cannot be regulated as satisfactorily.

"Most companies report that maintenance is low or reasonable on all parts of the equipment. One company reports that 90 per cent of control maintenance has been on that part applying to stoker speed. One company reporting on an air-operated system points out the necessity of supplying the system with clean dust-free air.

"The average automatic combustion control equip-

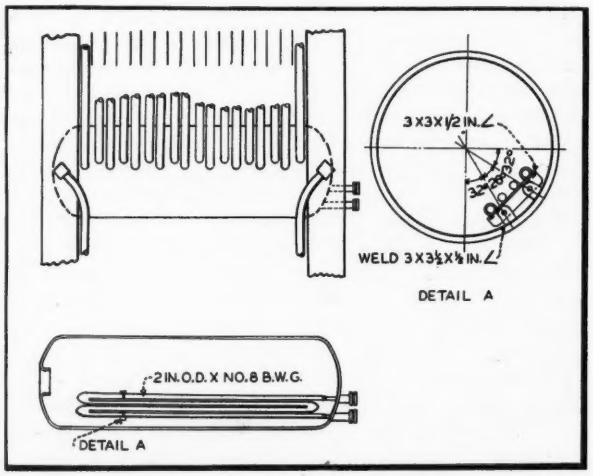


Fig. 2. A desuperheater as installed directly in the drum of an industrial boiler

ment is capable of handling the boiler unit from about 25 per cent to 100 per cent of full load. Two companies reporting automatic control used, satisfactorily, as low as 17 per cent of full load while two others set 20 per cent as the lower limit. On the other hand, two cases are reported with the lower load limit of 40 per cent of maximum. With one exception, all installations are capable of handling the boiler up to 100 per cent of maximum output.

"Nine companies state that the automatic control cannot be used to bring a banked boiler on the line. One company reports that it can be used if banked fuel bed is in fair condition. Four companies state that with minor manual adjustments and operations, the control probably could be used to bring on banked boilers. It seems, however, universal practice among companies reporting to bring banked boilers up manually to minimum rating mentioned above before automatic control is cut in.

"All companies agree that the greatest value of automatic control is realized on swing boilers, although it is very important on base load boilers as well. In the majority of cases reported, the automatic control varies load on all boilers although it is selective and can be used to swing one boiler or a group of boilers in certain cases. The choice of whether load swings are handled on one or more boilers seems to be a matter of plant or system conditions rather than limitations of control equipment.

"The only general conclusion that can be drawn from the statements regarding objectionable features is that these are complication and high cost. . . . A case has been reported of some difficulty experienced with coal feed regulation on a bin-and-feeder system. Coal feed is controlled by feeder speed and varying quantities of moisture affect the amount of pulverized coal that will be fed at any given speed, making frequent manual adjustments necessary. . . . "

It is of course unreasonable to expect the combustion control equipment to correct for characteristic deficiencies of the equipment to be controlled, even though that is very much a control problem. If a fan or coal feeder or valve has unstable operating characteristics the fault must be corrected before any combustion control system can be expected to perform properly. Inasmuch as changes or supplementary control would undoubtedly be charged against the control system, it is extremely important when selecting major equipment for a plant to give due consideration to the ease and adaptability with which each piece of equipment may be controlled by automatic combustion control equipment. If this is done the control problem is greatly reduced and economic justification for automatic combustion control, which is viewed in its true perspective, is seldom difficult.

The combustion control today solves two problems: handling equipment too large and complex for effective manual control; handling other equipment more efficiently and effectively than it can be done manually. The Connors Creek stokers are an excellent example of the first type. These large double ended stokers with a projected grate area of 557 sq. ft. (a larger area than a 23 ft. square) are, for control purposes, divided into 72 sections. Each section is provided with a Venturi throat with dampers under the control of a battery of 72 air flow regulators.

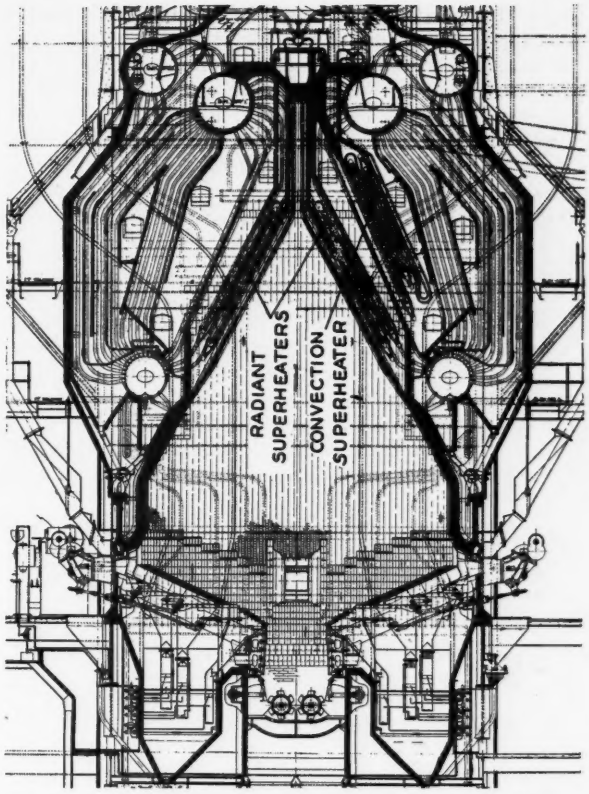


Fig. 3. Automatic temperature control of superheat at Connors Creek is by means of compensating superheater elements.

These regulators may all be controlled from one master regulator or may be controlled in sections of 12 by six zone controllers to meet varying conditions brought about by different load conditions.

Richmond Station, an example of modern control, is also of interest because of an innovation in color, the control panel being a light color. This change from conventional practice was made only after an extensive investigation of color and models to increase visibility and conform with modern lighting practice. The panel is of stainless steel and if in practice the reflection qualities are not satisfactory, a light colored paint will be applied.

At the University of Iowa where local low fusing temperature ash coal is being burned in underfeed stokers under the control of a new combustion system with the coal and air controlled by cams cut specially from draft loss tests on the individual boilers. Compensation for variation in fuel is made automatically from CO_2 readings. At Shelby compensation for air-fuel ratio variations is made from air flow-steam flow readings. At the oil fired installation of Massachusetts Institute of Technology a recently developed variable area flow meter is used in conjunction with a sensitive differential pressure diaphragm to maintain the desired air-fuel ratio.

The growing importance of natural gas in the middle west to boilers of all sizes, many with natural draft, has demonstrated fully the flexibility of modern control equipment. These control installations range from small diaphragm regulators up through pilot controlled regulators to the more extensive controls. With natural draft increasing furnace draft is

required with increased load. In one type of installation, especially popular in the Chicago region, the gas pressure at the burner is under control of the steam pressure regulator while the boiler outlet damper is under the control of a regulator sensitive to furnace pressure. The pressure actuating the regulator is, however, the furnace pressure modulated by the gas pressure at the burner, through a leak-off valve so proportioned that the desired air-fuel ratio is maintained over the load range of the boiler. As mentioned previously the developments along this line will be covered in detail in subsequent issues.

Regulation of feedwater was formerly separate and under the control of water level in the drum. With low pressures and large water storage in the drums such regulation gave excellent service and its characteristics could be adapted to help the boiler out as an accumulator for load swings. During recent years high pressure, small boiler drums and high steaming rates and pulverized fuel allowing almost instantaneous changes in the rate of fuel firing has complicated the feedwater control problem. Swell and shrinkage with changes in the rate of firing due to steam bubbles in the water also added to the difficulties especially in the medium pressure range and resulted in feedwater regulators becoming substantially part of the combustion control apparatus in that they are often made responsive to the steam flow as well as to the water level.

Normal practice in boiler control is to maintain header pressure within a comparatively narrow range of perhaps 5 lb. With high pressures the work of the boiler feed pump is an appreciable item, increasing in importance at partial loads and the Benson boiler, normally operated at critical pressure, may at partial loads be operated with variable pressure at least as low as 450 lb. per sq. in.

This permits operation of prime movers with constant temperature and variable pressure, which also allows simplifying the turbine design and to some degree improving its efficiency, particularly at fractional loads. This principle of constant temperature, variable pressure operation eliminates much of the turbine valve mechanism. The turbine has a single steam path, so theoretically, no valves whatsoever are required between the steam generator and the turbine steam path.

In any plant pressure control is often necessary for intermediate pressures. In the past these requirements have been successfully met with the usual pressure reducing valves. The advent of high pressures and high temperatures, however, introduced the additional complication of high superheat in the throttled steam and to meet this need desuperheaters were developed. Both the spray and cartridge types are widely used, water being introduced into the steam in such a proportion that the superheat is utilized in evaporating the water. Such combinations are part of all new high pressure modernized plants and are often used in new plants to supply steam for auxiliary or other needs.

Another type of desuperheater consisting of a number of tubes in the boiler drum, the superheated steam passing through them, has been used to some extent in industrial plants. One such design as used in the Palmolive-Colgate-Peet plant is shown by the drawing. The steam temperature is limited by the water temperature in the drum and is within the capacity of the tubes maintained nearly constant without additional control equipment. The heat given up goes directly into making more steam and of course forms a circulating heat load on the boiler but accomplishes the desired purpose in a simple way easily controlled. Substantially the same arrangement has been used for steam temperature control at the boiler to provide protection against excessive temperatures. A temperature controlled valve bypasses more or less steam to a drum desuperheater to maintain an even steam temperature. Other schemes, for instance admitting water to the steam at some intermediate point in the superheater has been used, one of the important points in this service being the protection of the last part of the superheater from excessive temperatures.

In normal extraction service steam pressure at bleed points is not controlled but is allowed to fluctuate with load. In industrial process and for heating systems such a fluctuating pressure is not desirable and it is necessary to fit the turbines with an internal mechanism usually tied in with the governor or provide external pressure regulation. The cost of such an integral device is considerable and the development of control equipment has been such during recent

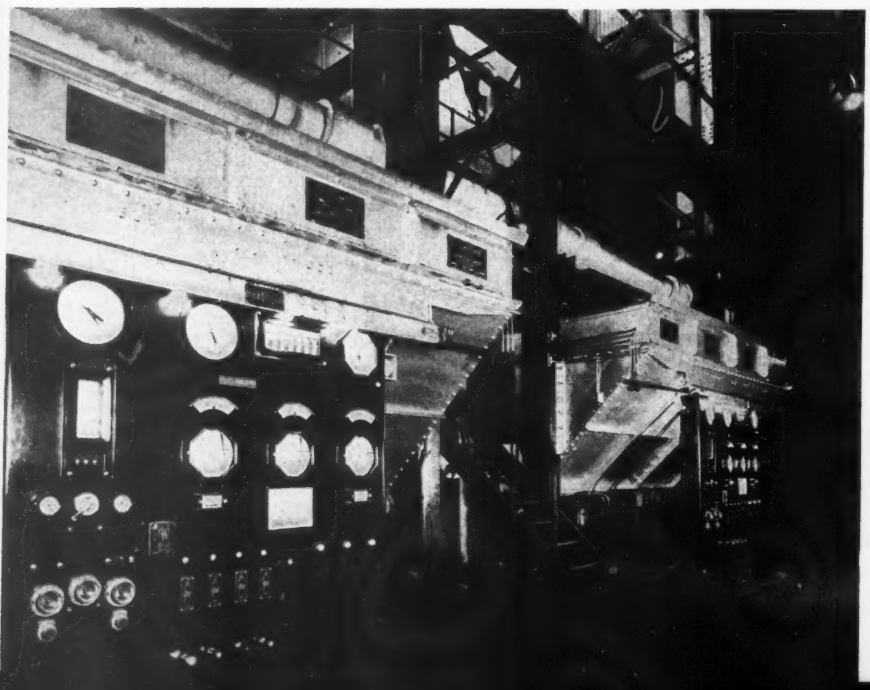


Fig. 4. Control Panel at Cos Cob Station where a modernization program was recently completed. (Photo, courtesy Republic Flow Meters Co.)

years that an external regulator may be used for many services at an appreciable saving in fuel cost. Shelby is an example of such practice. There an external control system maintains constant pressure on a heating system, using extraction steam up to the allowable limit and then automatically making up the deficit with live steam through a reducing valve and desuperheater. The control of the reducing valve and desuperheater combinations has been developed to a high state during recent years. Pressure control devices are used for a variety of purposes to meet local needs, thus at Fort Wayne, one of the most completely automatic stoker fired plants in the country, an electric pressure controller is used to maintain a positive pressure on the deaerating heater by opening a higher pressure bleeder line when the usual extraction pressure drops below atmosphere on low loads.

Open or contact heaters as used at Buzzard Point Station offer additional control problems. As with closed heaters, the extraction lines must be provided with check valves to prevent back flow of steam or water. Unusual levels must be provided against by suitable overflow connections and in practice the heaters have proved to be sensitive to quick changes in flow conditions, both from pounding and from trapping gases from the heater vent. At that station each heater is provided with a vent condenser and cascading of these vents with careful water flow control has resulted in a complete removal of oxygen even with concentrations of 1 c.c. of oxygen per liter admitted to the condensate.

Turbine governors are, of course, one form of pressure valve which have been highly developed to meet most rigorous conditions. During recent years development of interconnected systems and the tremendous sale of electric clocks has increased the rigorous duty, one system for instance maintaining the frequency within 1/20 of a cycle plus or minus. Inasmuch as one cycle of 60 cycle current represents a time interval of 0.066+ sec. it is seen that the governor has little time for thought so it is perhaps well that instruments cannot think but can devote all the time available to acting.

Heretofore, the turbine has been a simple piece of equipment which under the guiding hand of the governor conservatively turned on its way honestly believing that virtue was its own reward and honesty and perseverance were bound to win in the end. In its abstraction it quite forgot itself and under the stimulus of high temperatures and pressures outgrew itself. As a result these large machines have been subjected by specialists to an intensive instrument development so that the operating engineers will know what is happening inside at all times.

Instruments of course play an important part in the manufacture as well as operation of the machines, laboratory blading testing having done much to correct the early difficulties with blades for abnormal services. Then there are the machines for balancing the rotors. Newly developed electrical instruments indicate and record vibration, shaft eccentricity, cylinder expansion and noise on large turbines, Richmond being an excellent example of the most recent practice.

Turbines are subject to the same need of careful load control as are boilers if maximum station economy is to be obtained. This problem complicated by

Fig. 5. Testing the vibration of large low pressure turbine blades by means of special instruments.

the need for exact frequency regulation is not as simple as boiler loading but can be accomplished as demonstrated by the program control at Colfax Station where the units are automatically loaded according to a predetermined schedule.

This control meets the following conditions: Operates in conjunction with frequency, tie line, load or manual control; accurately distributes the load changes over the operating units in accordance with the prearranged load schedule; permits grouping units of equal increment heat rates so as to share load changes on such units equally; provides simple means for adjusting the load schedule; provides means to omit any unit from loading sequence when out of service or on special loading; provides continuous control with partial capacity, eliminating dead spots in control range; provides means for load regulation on one unit only without regard for load schedules when desirable; provides means for checking load schedule and correcting load deviations without forcing load changes on system. The control accomplishes this without interfering with normal speed control by the speed regulating governor; interfering with normal governor action during system disturbances; varying the load on any one unit above or below the full load or minimum load limits. The minimum load limit is usually set at about 15 per cent of the machine rating and full load is the nameplate rating, all overload operation being accomplished by manual control.

PRIME MOVERS *Enter a*

Gargantuan age superseded by popular demand for apartment sized models to handle high temperatures and eliminate need for reheat. Internal combustion engines gain rapidly.

WHILE THE "WORLD'S LARGEST" is still a phrase that rolls off the tongue with a smooth and sugary sound, it is no longer the ultimate goal and although at least one manufacturer has offered to build a 1200 lb., 1000 deg. F. turbine in any size up to 200,000 kw., it is probable that State Line will hold the record for some time against the onslaughts of the modern steamlined units.

There is, however, a continued interest in pushing up the size of 3600 r.p.m. machines and due to recent generator developments, the upper allowable limit of these machines has been boosted to 62,500 kw., although the largest machine of this type to be built, or, rather ordered, to date is the 1250 lb., 925 deg. F., 40,000 kw. unit for Logan Station of the Appalachian Electric Power Co. Following extensive experience of this company with hydrogen cooled converters, this unit will be hydrogen cooled and will undoubtedly rank as one of the major developments of the coming year.

Fig. 1. Port Washington shines forth as a beacon in the utility field. (Photo, courtesy The Milwaukee Elec. Ry. & Light Co.)

The pioneering contributions of the American Gas & Electric System into the development of the industry probably cover a broader field of activity than any other utility organization. Looking back over the past few years, their activities in the reheat and extraction cycle, hydrogen cooling and outdoor construction, the new adjustable blade hydraulic turbine, the application of electronic devices to the plant and power system and the high temperature turbine mentioned above, cover but a few of the most important developments in which the company played an important role.

Both from the standpoint of size and interest to prospective modernization projects, the 165,000 kw. Richmond turbine is the most important unit of the year. By retaining the original steam pressure of the station, 375 lb., but increasing the temperature to 825 deg. F. and taking advantage of advances in construction, this unit was installed in space originally intended for a 50,000 kw. unit. This ratio holds good for the boiler as well as the turbine room. The most efficient load is at 135,000 kw. and the tip speed of the low pressure blades are somewhat over 900 ft. per sec. The unit occupies an area 96 by 38 ft. and stands 26 ft. above the floor. Problems involved in construction may be made more apparent by knowing that the rotating mass weighing almost half a million pounds revolves at a speed of 1800 r.p.m. and must be balanced so perfectly that clearances, measured in thousands of an inch, may be maintained. Development of balancing machines for this service is one of the important developments of recent years.

Remarkable as turbine development has been, condenser progress due largely to the use of welded steel shells has kept pace and installation of 17,000 tubes representing 113,000 sq. ft. of condenser cooling surface for the above unit is no mean accomplishment. The condensing capacity of 1,600,000 lb. of steam per hr. requires 155,000 g.p.m. of water with a temperature rise of about 20 deg. F. and making a single pass through the shell. This water is pumped by two vertical motor driven pumps.

Disastrous fires of recent years resulting from the contact of oil with parts heated by high temperature steam forced attention on corrective measures for the governing and lubrication systems. The danger might have been eliminated by replacing the oil by some non-

New Phase of Development

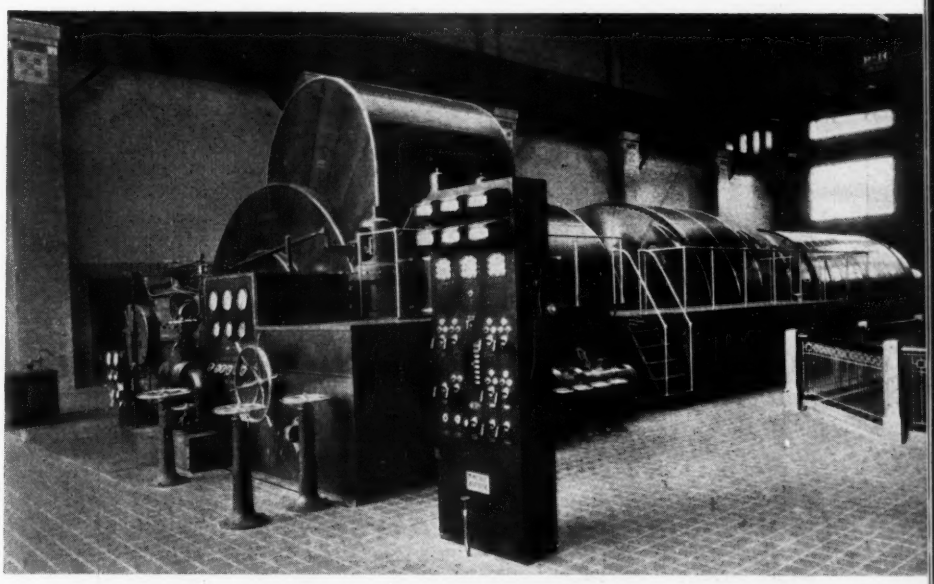


Fig. 2. The tandem compound Port Washington turbine is built for reheat, the reheat openings being in the high pressure cylinder. Designers of this station led the break in temperature from the conventional 750 deg. F. (Photo, courtesy Allis-Chalmers.)

inflammable material without change in equipment. Although several materials offered possibilities along this line, none proved entirely satisfactory from the lubrication standpoint so the only alternate was selected, that is separation of the governing and lubrication systems. Oil is used in the latter but aroclor, a non-inflammable liquid with some lubricating properties, was selected for the former. This system as used with the Richmond turbine will be described in detail in a later issue.

Another turbine of importance is the 100,000 kw., 1400 lb., 900 deg. F. vertical compound condensing turbine for the Ford Co. This unit, practically a duplicate of an earlier 750 deg. F. reheat machine, demonstrates the plant simplification and increased economy made possible by the increase in temperature. Comparative performance figures of the two units are given in an earlier article. The output of the larger machine will be supplemented by a 12,500 kw., 250 lb. back pressure turbine with the same throttle steam condition as its larger neighbor.

A few of the more interesting turbine units now under construction are: Two 60,000-kw. units for the Detroit Edison Co. will be the largest 600-lb. steam pressure units for the high temperature of 825 deg. F.; a 30,000-kw., 1500 r.p.m. unit owned by the New York Edison Co. is being rebuilt for 40,000 kw. and 1800 r.p.m.; a 10,000-kw., 3600 r.p.m. non-condensing unit for the Weirton Steel Co. will operate on 800-lb., 800 deg. F. steam and exhaust at 215 lb. back pressure; a 12,500-kw., 3600 r.p.m. non-condensing turbine being built for the Virginia Electric & Power Co. will operate at 850-lb. steam presure and 825 deg. F. temperature.

Small turbines are being continually improved especially for auxiliary service where it is desirable to have them operate from header pressure without need for reducing valves and desuperheaters. In Europe one manufacturer has abandoned axial flow designs for small units of this type and developed a complete line of radial flow turbines for industrial use. In some of these units steam is admitted at the shaft and flows outward, in others it is admitted at the periphery, flows inward, is reversed and again flows outward to the exhaust, traversing a U-shaped path. The design is said to be efficient, simple, compact and easy of access.

From this discussion of turbines it is not to be inferred that engines have passed from the picture. As a matter of fact, engine design has progressed during recent years and is still the preferred type of prime mover for smaller plants where efficiency is a prime consideration. The Rockland State Hospital with four engine generator sets totaling over 2000 kv.a. is a recent example of a more or less conventional type of plant that has proved its reliability and serviceability over years of industrial and institutional experience. Perhaps the greatest advance in the engine field has been in small auxiliary engines and generator sets for modernization projects. The fact that new equipment developed for specific needs and advanced application and heralded by headlines should not blind the engineering profession to the fact that the backbone of the industry is still found to consist of the same fundamental equipment as a decade ago, much improved but fundamentally the same.

Condensers have perhaps undergone as much of a dressing up as any other piece of equipment in the plant. Welded steel plate shells have revolutionized construction and done much to reduce weight and air leakage and give additional flexibility. Detailed studies have increased the performance largely by improved tube arrangement and laning.

Condenser tube erosion and corrosion continues to be a problem with certain waters and although special alloy tubes have been experimented with extensively, none of them offer a universal remedy. In fact, the experimental and practical data are so widespread and conflicting that they are difficult to correlate. Some companies have had considerable success by painting the ends of tubes with special paint to give a

physical protection without appreciable effect on heat transfer.

Chlorination of circulating water has proved to be an effective method of combating slime growth especially troublesome in districts where water is polluted with sewage. A summation of 1½ yr. experience at Essex Station, one of the pioneers in chlorination as made for the E.E.I. probably covers typical results for a well operated station. The summation follows:

"The old hand cleaning evidently was done so thoroughly that there was little improvement in operating vacuum; tube surfaces and water boxes are slime free and the walls of the intake and discharge canals are almost entirely free of the usual slime growth; no deterioration of tubes or ferrules has been noticed which may be charged to the action of the chlorine; availability of turbines increased due to less condenser outage for cleaning; since chlorination started no cleaning has been done other than weekly examination of water boxes for removal of rubbish lodged in tubes."

Several engine manufacturers have already made arrangements to rebuild or extend their present plants. Last year's production of Diesel and semi-Diesel engines was approximately three-quarters of a million horsepower and predictions were made at that time that a total of one and one-half million horsepower would be produced in the year 1935. It is too early to say whether these predictions will prove correct but it is certain that the year's output will be over one million horsepower.

—M. J. Reed before A.S.M.E.

Remarks about deterioration of tubes and ferrules agrees with the statements of the manufacturers of the chlorinating equipment which are to the effect that: "In no case, where proper chlorination is practiced, have reports of accelerated tube corrosion been substantiated by records of shortened tube life." Conclusions do not, however, agree with the findings at Long Beach station where an extensive experimental investigation was made before installing complete chlorination.

In order to determine if the use of chlorine caused an increased loss of tube material, one condenser of each unit was fitted with a tube which could be easily removed. Before being installed each tube was carefully cleaned, and weighed with scales having an accuracy of 0.1 per cent. To determine the tube loss attributable to chlorination one unit was operated without chlorinated circulating water while the other unit received chlorinated water. The two units operated this way for approximately 1400 service hours and 2000 service hours, respectively.

At the end of this time the tubes were each removed, carefully cleaned and weighed. From the loss in weight and the operating time the per cent loss per year was computed. For the non-chlorinated tube, this amounted to 5.5 per cent per year and for the tube receiving chlorinated water 11.6 per cent per year, leaving a difference of about 6 per cent per year which was charged to chlorination.

Periodic checks on the removable tube that has been subjected to chlorine treatment from the beginning showed that the rate of loss of material has continually decreased since the start. As mentioned above, this loss was 11.6 per cent per year after 2000 service hours but after 8000 service hours, decreased to about 5 per cent per year. This decrease in rate of loss might be due to the formation of a protective coating which resists the attack of chlorine.

Tests of weighed tubes together with visual observation and inspection indicate that corrosion due to chlorination alone is not as serious as was formerly supposed. Perhaps the decreasing rate of corrosion is responsible for the fact that although corrosion is apparently present it is not of sufficient importance to actually shorten tube life so that the conflicting statement may be reconciled for all practical purposes.

Internal Combustion Engines

As it was last year, the most spectacular development in the Diesel field was in connection with railroad locomotives. The new four engine locomotive for the Santa Fe Chief was perhaps the most practical development along this line to date and the unfortunate fire which cut short its proposed maiden record run from Chicago to Los Angeles should not dim the glory of the achievement from the designers' standpoint.

Although less flashy than the new streamlined high speed trains, the new locomotive is as powerful as a regular passenger locomotive and was designed to pull a standard De Luxe train, the Super-Chief, on its regular run. The locomotive is built in two identical sections which may be operated in either direction singly or together. Each section has two 12 cyl., two cycle, 900 hp. Diesels, a 90 hp. auxiliary unit, a heating boiler and 1600 gal. of fuel oil. The engines weigh less than 20 lb. per b.hp. Steam for heating and air conditioning the cars is supplied by a compact, automatic, oil fired boiler with a steaming capacity of 2000 lb. per hr. of 200 lb. steam. The unit, weighing 250 t. and measuring 127 ft. in length, has a traction effort of 120,000 lb. at starting and 19,000 lb. at 60 m.p.h.

Each engine is direct connected to a single bearing direct current differentially wound generator which furnishes its output to two unconventional series-wound direct current motors mounted on the truck. Approximately one-half of the motor weight is supported on the axle and the remainder by a nose supported on springs. Each traction generator has a direct-connected exciter which furnishes its entire out-

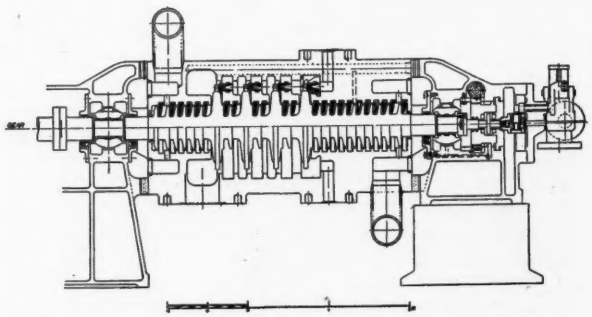


Fig. 3. Cross section of a proposed 2500 kw. turbine.

put for excitation of the main generator. The generator has a sturdy anti-friction armature bearing at the commutator end. The volt-ampere characteristic of the generator matches the motor characteristic to give full engine output over a wide range of locomotive speed. The generators are connected to the engines by a flexible steel disk coupling, so arranged that it carries a part of the armature weight.

Four traction motors in each section take the full output of the two 900-hp. engines. The motors are of the single-geared commutating-pole type, with provisions for taking ventilating air in through the top of the magnet frame over the commutator. The armature bearings are of the anti-friction type and the axle bearings are of the waste-packed type having large oil reservoirs and are fitted with spring pads to hold the waste packing in openings of the axle linings. The motors have been specially designed for traction service to withstand high speeds and at the same time give high tractive effort.

High thermal efficiency of the Diesel engine has made the Diesel-electric locomotive a part of modern transportation equipment. The fuel consumption of the engine ranges from 0.38 to 0.43 lb. of fuel per b.hp. hr. with fuel oil of 19,500 B.t.u. per lb. This rate of fuel consumption corresponds to an engine thermal efficiency of from 30 to 35 per cent, as compared with 5 to 7 per cent efficiency of modern steam locomotives. Modern electric drive includes generators which have an overall efficiency at normal load of 93 per cent and traction motors with an overall efficiency, including gears, of 90 per cent, with a resultant overall transmission efficiency of 84 per cent.

Control panels for each generator and its two motors are in a compartment directly above each generator. Two radiator fans at each end of the locomotive are driven direct from the main engines through V belts. The auxiliary engine in the central part of the cab drives, through V belts, a 150 cu. ft. air compressor and traction motor blower set, as well as a direct-connected 25-kw., 75-v. auxiliary generator for charging the battery, for operation of lights and other auxiliaries. Electric starting of the engines is provided by this battery.

The auxiliary generator is of sufficient capacity to maintain its full rated voltage and capacity under all operating conditions. The voltage is held constant by means of a voltage control relay. The control for the traction motors has been designed for simplicity and reliability. The auxiliaries are assured an adequate supply of power under all operating conditions.

A 10 cylinder, 2200 hp., 165 t. transfer locomotive ordered by the Illinois Central uses a V-type 600 r.p.m. Diesel of the truck piston two cycle type, fitted with an integral rotary scavening blower. Made of usual materials, this engine weighs about 32 lb. per hp. but it is said the weight may be reduced to 23 lb. by the use of special materials. An experimental engine of this type showed a flat fuel consumption curve with a low point of 0.392 lb. per b.hp. hr.

The Comet, The Rebel, The Flying Yankee set new standards in rail transportation while the Mark Twain Zephyr claims the record of 122 m.p.hr. over a considerable distance and the world's fastest, regular, long run will soon be added on the Union Pacific from

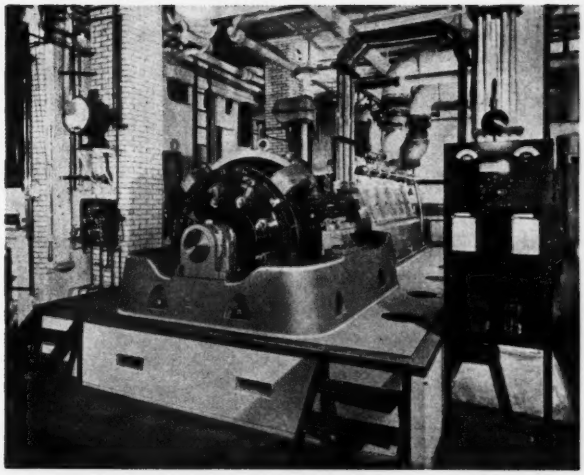


Fig. 4. The 350 kw. Diesel unit installed in the Singer Building for combination steam and Diesel operation. (Photo, courtesy Winton Engine Co.)

Chicago to Denver, a run of 1048 mi. at an average speed of 65.5 m.p.hr.

In the stationary field Diesel progress has not lagged. The Singer Building and Litchfield, Minn., combination steam and Diesel plants have been mentioned in an earlier article. Culpepper, Va., completed a 1040 hp. engine plant with PWA funds early in the year and the government is now completing a 1750 kw. Diesel plant on the San Carlos Indian Reservation near Coolidge Dam in Arizona.

In the larger sizes Diesels have proved reliable and effective prime movers for both regular and standby service and the new station of the Imperial Irrigation District in California should provide valuable experience on combination and hydro and Diesel systems on irrigation projects. Utilization of the water for irrigation after utilizing all available head for power is beating the stockyards at their own game and in this scheme the use of Diesels for standby power is ideal.

In Europe engines have been used more widely for this service, the largest Diesel plant in Europe, St. Gallen-Appenzell, using three 7400 hp. engines for this service. Tests show that the first engine can be ready for service 1½ min. after the operator enters the room and the entire plant in 5 min. In Italy two 5000 kw. units replaced steam in the Montemartini station near Rome. This is also standby service for a hydro system and as Mussolini tolerates no delay the contract states that the engines must pick up the load 60 sec. after the demand.

The world's largest Diesel station in Shanghai has a recent addition of 13,700 hp. bringing the total capacity up to about 30,000 kw. The engine, designed for continuous output of about 8000-kw. generator output, has eight cylinders and runs at 136 r.p.m. Fuel injection is by air supplied by two three-stage compressors mounted on the engine. This method of injection was adopted in order to permit using fuel with high asphalt content. Scavenging air is provided by a double-acting tandem pump integral with the engine.

At Copenhagen a 15,000 kw. engine has been installed for standby service at the Oersted plant and a limited amount of operating data is available. Maximum efficiency is at 12,500 kw. Fuel is injected at a

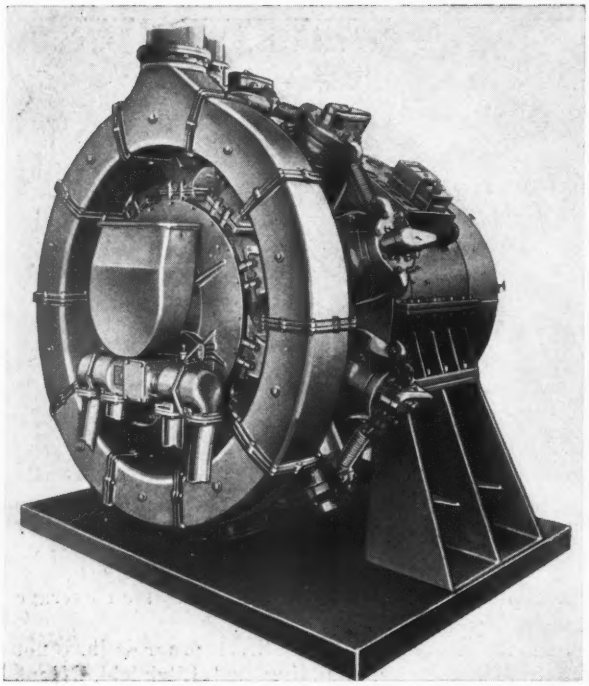


Fig. 5. A new radial Diesel for general service built in 5, 8 and 10 cyl. sizes. (Photo, courtesy Continental Motors.)

pressure of 6000 lb. per sq. in. through three atomizing valves at the top of the cylinder and three at the bottom. Scavenging air is supplied by rotary blowers, requiring about 1200 hp. in connection with a large scavening tank. Cylinders are cooled with fresh water and pistons with lubricating oil, both being cooled by sea water. Cooling water leaves at 175 to 195 deg. F. and is used for heating of buildings. The unit is about 40 ft. high and 80 ft. long. Fuel oil with specific gravity about 0.9 is used; the fuel consumption, based on the assumption of 18,000 B.t.u. per lb., is: 15,000 kw., 0.55 lb. per kw.; 12,500 kw., 0.53; 9400 kw., 0.54; 6250 kw., 0.58. This unit can be started and synchronized in 1 min., 40 sec.

Supercharging is increasing in use, especially for marine work, the latest development being the Wibu supercharger system which makes use of the inertia effect of air in the suction pipes. It is said to be easy to apply to existing engines and in a typical installation increase the capacity from 240 to 300 hp., representing an increase in m.e.p. of from about 80 to 100 lb. per sq. in. It may be used in conjunction with blowers.

A number of new designs have been developed including a rotary Diesel engine of five, eight or ten 6½ by 7½ in., 2 cycle cylinders delivering 225, 360 and 450 hp. at 900 r.p.m. The large unit weighs 3900 lb. A new axial engine was developed in England for bus service. Horizontal cylinders laying in a circle thrust on a rotary water cooled swash plate and a non-rotating member on a Z shaped axis completes the design which is said to be giving good service. For some time the Diesel has been having a trial in Boston busses. It is said that the combustion chamber design used successfully eliminates objectionable exhaust gas odors but detailed reports of operation and economy are not yet available.

High speed Diesel development continues at speeds of from 800 r.p.m. up and the effect of the higher speed on engine weights is shown by one line of small Diesel sets where an increase in speed from 720 to 1200 r.p.m. cuts the weight in half. These engines range from 5 to 100-kw. in size and the generator efficiencies range from a minimum of 78.5 for the small sizes to 92.4 for the larger ones. Almost all manufacturers of this type engine offer units for mechanical drive, industrial service which includes engines, auxiliaries and radiator mounted on a steel base with clutch, extension shaft and pulley and on the larger sizes, outboard bearings. Running speeds of these units may vary over a considerable range to meet specific conditions and the governors are adjustable to meet these requirements. One company which started to build engines of this type in 1931 recently completed its 10,000 engine.

Introduction of the high speed engine further complicated the Diesel fuel situation and users in conjunction with oil refiners felt the need for standardization. This has been done and specifications have been standardized by an A.S.T.M. committee under five standard grades. The knock problem is more difficult but standard test engines have been developed and work is being carried forward not only by engineering societies involved but by voluntary coöperative effort of a number of research laboratories.

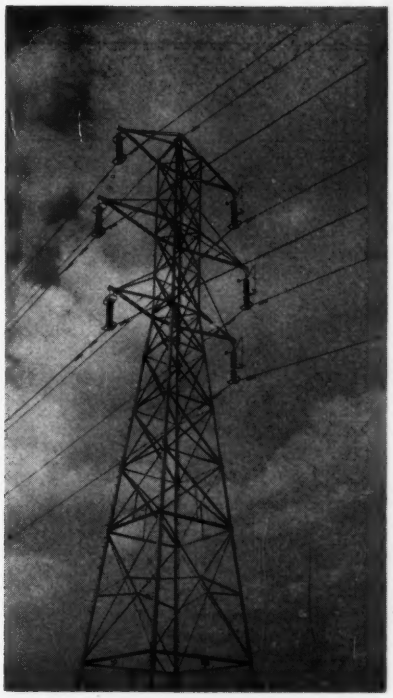
In discussing the Ignition and Combustion of Diesel Fuels before the A.I.M.E. Boerlage and Broeze said:

"Pressure diagrams show that, following the injection of fuel into an engine, there is a delay prior to the main pressure rise. This delay has been described as a warming-up period during which the temperature of the fuel is approaching that required for a flame to start. However, closer inspection of the diagram indicates that not only does the pressure often decrease at first suggesting the absorption of heat resulting possibly from vaporization or decomposition, but that it may then increase by as much as several atmospheres before the rapid combustion sets in. We prefer, therefore, to conceive of the delay time as an active period during which reactions occur which develop heat. As soon as the temperature at some point becomes sufficiently high the flame starts, which has been found to follow the laws of flame combustion.

"This second period is one of uncontrolled combustion and is followed by a third period during which the combustion is controlled by the rate of fuel injection. With slow-speed engines in which the delay period is short compared with the total time of fuel injection, the combustion curve has a smooth character, however, with high-speed engines, the first and second periods become more distinct.

"In general, the efficiency and power of an engine depend primarily on the ignition delay of the fuel and the completeness with which it is distributed within the combustion space. The latter is chiefly a design problem; the former is dependent upon the type and treatment of the fuel. While poor fuels can be improved by mixture with dopes such as peroxides or nitrates, such treatment is expensive and can generally be dispensed with if the fuel is prepared from selected crudes. Since these crudes are in general the ones which are least desirable for the manufacture of gasoline, the expansion of the use of Diesel engines really need not produce a serious drain on the available supplies of fuels for gasoline engines."

Encouraging Outlook for the ELECTRICAL INDUSTRY



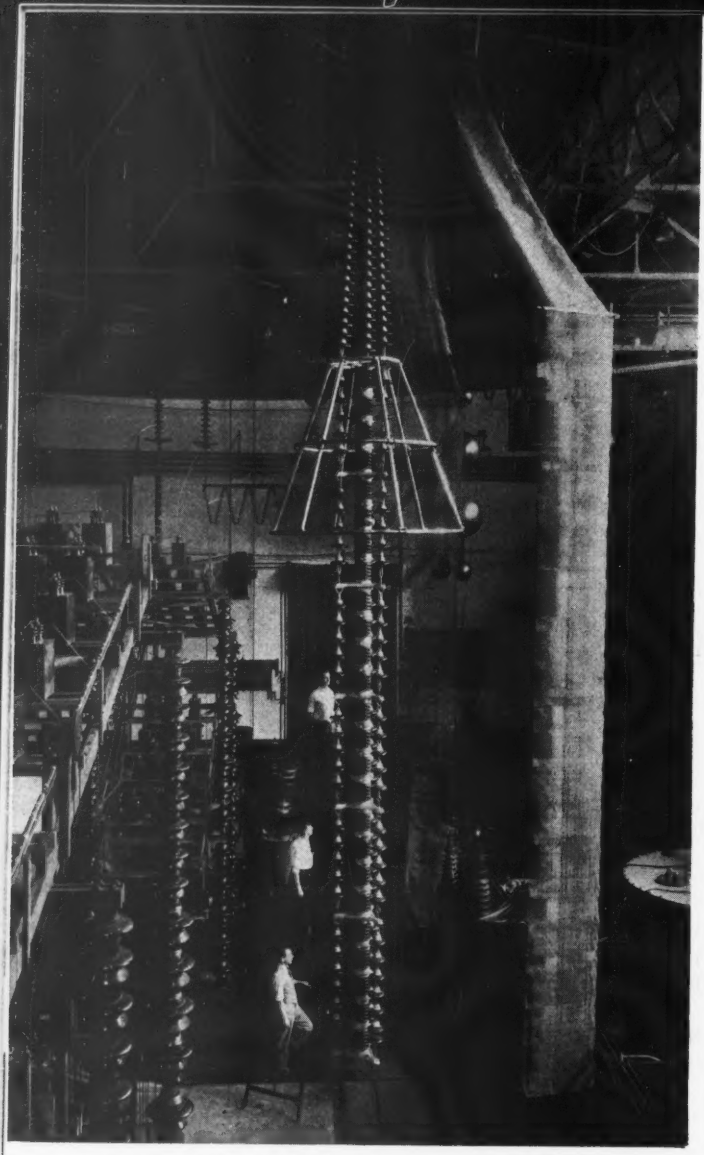
Expulsion gaps on 132-kv. Glen Lyn-Roanoke line of Appalachian Electric Power Co.

IN PRESENTING this review of the year's developments in the field of Electrical Engineering we are conscious of the limitations which necessarily restrict us in presuming to undertake so formidable a task. The electrical field is so vast, so all-inclusive, and development in all its varied branches so rapid that it is impossible to present more than a superficial analysis of it in a brief review such as this. The electrical field, today, involves every phase of human activity — power, communication, transportation, amusement, health, food, agriculture. It is so interrelated with all other industry that often it is difficult to mark the boundary lines between the purely electrical activities in an industry and those relating primarily to that industry. Thus, several months ago, General Foods, Inc., took out a patent on a new electric, ultra-violet lamp while, almost at the same time, the General Electric Co. applied for a patent on a new type of lily. Similarly, the communication engineer finds himself engaged in the development of musical instruments and the radio technician invades the field of bacteriology and medicine.

In transportation, electricity has played a dominant role for many years but today with the rapid progress in the field of fast, light weight trains, it is becoming increasingly important. So also in the marine field, the electrically propelled ship is the order of the day and an event of world wide importance during the year was the new trans-Atlantic record attained by the Normandie, the world's largest electrically propelled ship. In the theatrical field—amusement—electricity has dominated stage technique for many years but new methods and new uses in the application of electric power to the stage are being discovered every day. The motion picture as we know it today would be utterly impossible except for the electric arc and now with the perfection of "sound" technique the entire motion picture industry more than ever before rests firmly on an electrical basis.

In the diagnosis and treatment of disease, the X-ray and the ultra-violet lamp and the so-called radio knife are continually finding new and more useful applications, and in quite another direction—in music—electricity promises to revolutionize the entire art. In an interesting little book,[1] John Mills of the Bell Telephone Laboratories tells what electricity is doing for music—how the years of concentrated effort and investigation in sound by telephone engineers, have provided us with knowledge which makes possible musical instruments of an entirely different kind than those we now have; that is, electrical musical instruments. In the metallurgical art, the application of electrical heat has opened up new possibilities in the production of new and remarkable alloys and the rapid development of the art of electric welding has revolutionized manufacturing processes in scores of industries. The importance of electricity in the communication art need scarcely be mentioned, our entire commercial civilization is dependent on it, but only those actually connected with the electrical communication field can have any idea of the enormous development which constantly characterizes every branch of that field. When Edison invented the quadruplex telegraph which would carry four messages in each direction simultaneously, it was considered marvelous, and justly so. But compare that accomplishment with the fact that today, with the new concentric conductors or balanced telephone lines, we can carry 240 separate telephone conversations over a single pair of conductors without the slightest interference and you will obtain some idea of the progress that has taken place

[1] "A Fugue in Cycles and Bells," D. Van Nostrand Co., Inc.



One of the Giant Lightning Arresters for the Boulder Dam line on test. (Photo, courtesy General Electric)

since Edison's day. And so, in every conceivable branch of human endeavor, electricity finds new applications and brings about improvements.

In looking back over the year's engineering conceptions, one gains renewed confidence that we are truly advancing in civilization—social and international problems notwithstanding. With insatiable curiosity, scientists, engineers, technicians, are forever breaking new trails forward to new discoveries. The pioneers follow, some branching off here and others there to develop one or another of these discoveries. But each new path opened reveals starting points for new trails leading to still new possibilities.

So much by way of introduction. Specifically, we are here interested in the generation and distribution of electric power and its utilization in industry and in the home. With this in mind a factor of foremost interest, this year, is the remarkable increase in the use of electric power as reflected by the steadily rising load curve. This increase in use is nothing short of phenomenal in view of conditions generally. Since the latter part of May, the energy output has been steadily above that of the corresponding period for the highest previous year, i.e., 1926, and since the latter part of September the output has been far above the all time peak which occurred in December, 1929. Since June the movement has been continuously and vigorously upward but recently there has been an added upturn, so that the curve for 1935 is drawing away from both 1929 and 1934.

This rising curve (it has been steadily upward since May, 1933) during the depression period and its remarkable present upward slope is of even greater importance than as an indicator of better general conditions; it marks a fundamental change in the attitude of people to the use of electricity, not only a greater appreciation of its value but something even more fundamental; an inherent need for it. As can be shown, the increase in the energy output of the country is due largely to an increase in the domestic load. Electric power is fast becoming an integral part of our daily existence and the time is coming when we will regard electricity in much the same way as we do water, and sidewalks, and public highways. Indeed, with our vast resources, we are approaching a point where the cost of power will no longer be measured in terms of its scarcity value.

It is because of this more intimate relation between electric power and our national life that the power question has become more or less of a national issue and that it has found its way into politics. To many this seems unfortunate since politics has an unsavory reputation and they believe that the electric light and power industry can best function under private management and with a minimum of governmental regulation. However that may be, the fact remains that the utility industry must be operated to serve the best interests of the greatest number, and it is inevitable that the question will remain in the limelight for a long time to come. Just exactly what changes the future will bring no one can foresee nor do we venture to predict but one can rest assured that the public's interest will be preserved. Electricity is too great, too vital a force in our national life to be controlled or limited in its application in the interests of a minority.

Despite the alleged political restrictions claimed by the utilities and advocates of private ownership, the industry as a whole has prospered during the year. The rising load curve is a significant indicator of increased activity and it is rapidly bringing the utilities to a point where it will be necessary to extend their

Motors in Steel. Motor Room of Tandem strip Mill, Youngstown Sheet and Tube Co. (Photo, Westinghouse)

available generating capacity. While there is probably no danger of an actual power shortage as implied in the interim report of the National Power Survey[2] issued early in the year, it is quite apparent that new generating capacity will have to be installed in the very near future if the rise in the load continues. During the past five years very little new capacity has been added, but up to the present there has been ample reserve because of the fact that the industry was overbuilt. In view of present design factors and the low operating costs of modern equipment much of the existing capacity is obsolete and while this equipment is well suited to handling emergency peak loads that may arise, it is not sufficiently economical for continuous service.

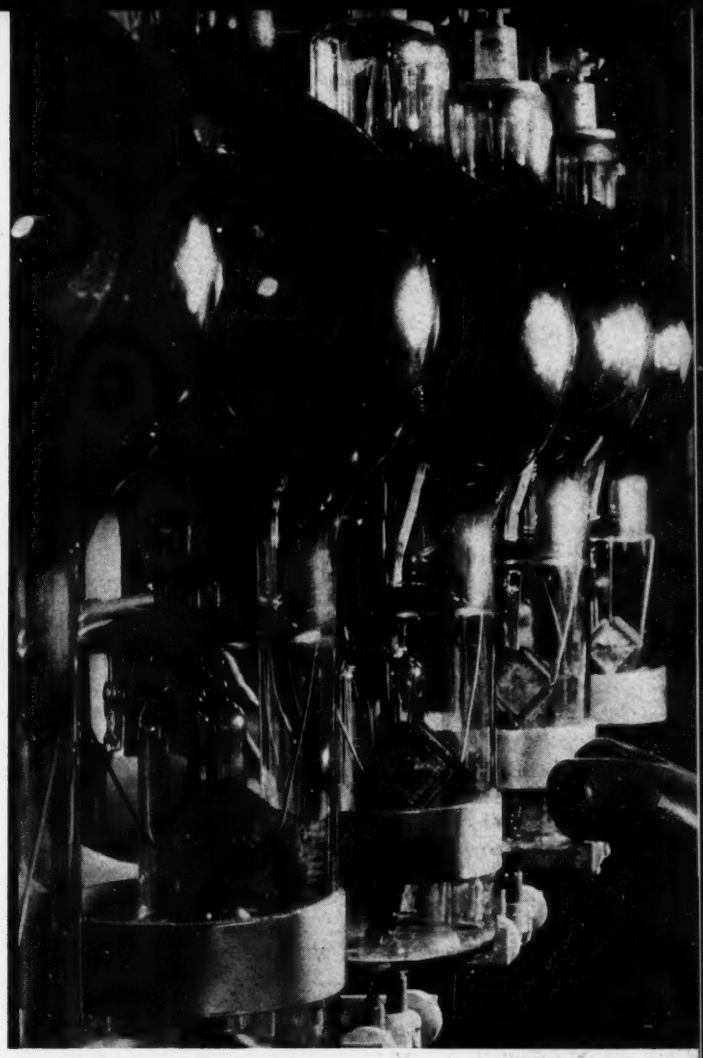
In terms of revenue from operations the utilities this year have made remarkable gains and during the latter part of the year the revenue has not only greatly exceeded the corresponding period for 1934 but has exceeded even that of 1929. It is true, that this increase in revenue is not all reflected in profits since operating costs and taxes are higher. Even though the domestic load has increased greatly, the total domestic load represents less than one sixth of the total sales of the utilities. Industrial power, which represents the bulk of the sales, because of the competitive influence of private plant operation, is now selling at nearly the lowest price in the history of the power business.

The electrical manufacturing companies, with few exceptions, all report considerable gains in sales and earnings. At the time of this writing the figures for the fourth quarter have not yet been compiled but during the third quarter of 1935, orders for electrical goods reached a higher value than in any other equal period since the summer of 1931.

The total 78 electrical manufacturers reporting regularly to the Bureau of Census announced orders amounting to $141,691,889 for the third quarter, an increase of 41 per cent over the $100,334,150 in the third quarter of 1934.

While few new plants or extensive additions to existing stations have been started recently, a large number of projects are under consideration and if the load continues to increase, as there is ample reason to expect, the coming year should bring even more new business to the manufacturing companies. Another encouraging factor is the recent United States-Canada trade treaty which has gone into effect. Whatever opinion other interests might have regarding this pact, certainly the electrical manufacturers have no reason for protest. The treaty imposes scarcely any new competition for factories in the United States while the lowered export duty on a large list of electrical products, ranging from wire and copper and brass manufactures, through vacuum cleaners and electrical refrigerators, places the American manufacturers in a much more advantageous position. Indicated annual shipments across the northern border in these classifications run around $40,000,000 and reductions in some duties are quite large.

On the whole, the electrical industry, today, is in a strong, healthy condition. Technically, financially, socially and politically it is progressing and though it may be beset with difficulties in some of its social and political phases, these are not unsurmountable and though it may take time we can look forward to a future when they will all be straightened out.



Margaret Bourke-White.

Array of rectifier tubes in WOR's 50-kw. Transmitter at Carteret, N. J. (Photo, courtesy Western Electric)

The development of electrical progress, thus far, may be divided into four phases. First, there was a clearly defined path towards the development of more powerful, more economical and more varied apparatus for power and communication purposes. This, of course, still continues but in late years a second stage developed. This manifested itself in a universal urge and effort on the part of physicists seeking understanding of the constitution and electrical behavior of atoms and electrons. Still more recently a third stage became evident, the study of electricity with respect to physiological and psychological matters, the use of electricity in the treatment of disease and as a contributing factor to our greater comfort—hearing, seeing, feeling. And now a fourth stage is beginning—the conception of electricity as a factor in the development of a higher social order—its social significance in communication, transportation, utilization of the world's energy resources. And in that direction lies its greatest power. Socially it offers the world a future such as few dreamers of Utopias ever dared prophesy.

[2]Interim Report, Power Series No. 1. National Power Survey, Federal Power Commission, 1935.

Electric

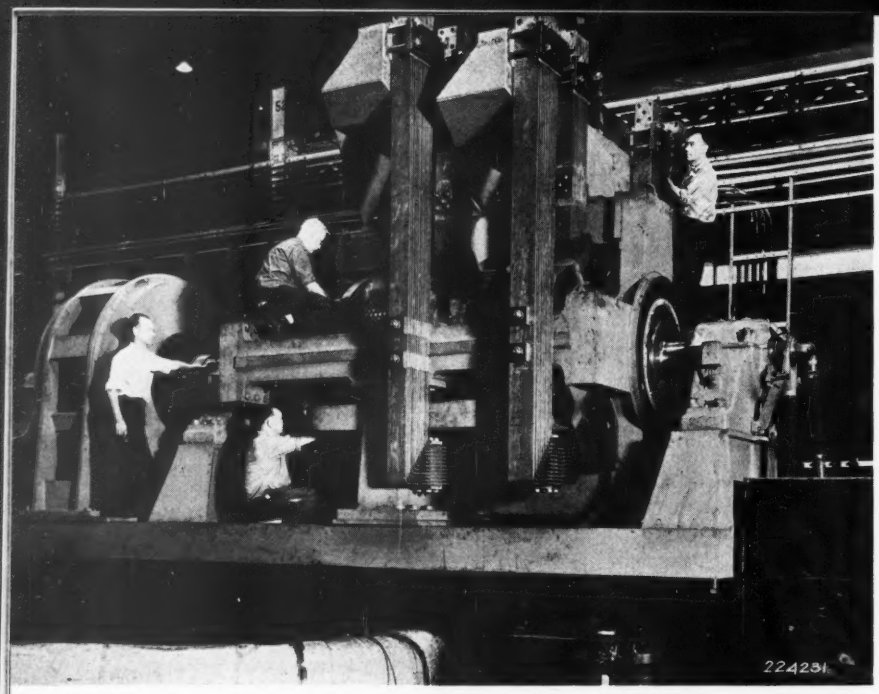


Fig. 1. 150,000 Amperes without a commutator. Large Homopolar generator delivers 150,000 amp. at 7½ v. The machine has 1400 brushes, cooled by specially humidified air. (Photo, courtesy Westinghouse)

IN TERMS OF NEW, large units, progress in the electrical power field during the past year was insignificant compared to that which characterized years of the heyday of our prosperity—1927, 28 and 29. Only one new station with only a single generating unit of 80,000 kw. went into service, the Port Washington Station near Milwaukee, and only one other large turbine generator was added to an existing station. This was the 183,333 kv-a. unit at Richmond, the largest in the world.

However, turbine generator progress is measured not alone in terms of large units and quite a considerable number of small units have been placed in service during the years of the depression. Most of these have been for ratings of less than 10,000 kv-a. and operating at 3600 r.p.m. The purchases in general have been by municipalities and by industrial enterprises.

With waterwheel generators, the situation is quite different. Because of the many large government hydro-electric projects in course of construction, many large waterwheel generators have been manufactured during the past few years, among them the Boulder Dam units which are the largest in the world. The initial units for Boulder Dam are now being installed and they will go into operation in 1936. These units, consisting of four 82,500 kv-a. and one 40,000 kv-a. unit, were fully described in the June, 1935, number of "Electrical Engineering." [1]

The two 56,000 kv-a. generating units being installed at Norris Dam possess a number of unusual features. Among these is the telescopic exciter design which, compared with the usual "umbrella" type of exciter arrangement, resulted in a reduction in headroom of nearly 3.7 ft.[2] Aside from the reduction in cost which may or may not result from this decreased headroom, the telescopic arrangement results in a more compact design, lessening the tendency for the exciter shaft to become eccentric and out of balance.

Among other large waterwheel generators under construction, the 36,000 kv-a., 85.7 r.p.m. unit for the Joe Wheeler station of the TVA is notable because it is the largest outdoor generator ever built. It will be equipped with surface coolers, a cooling arrangement that is becoming increasingly accepted as highly desirable not only for outdoor machines, but for indoor machines as well. Other machines in course of construction are the two 48,000 kv-a., 75 r.p.m. waterwheel generators for the Bonneville development on the Columbia River. In general, these units are of conventional design but will have totally enclosed features and will be equipped with surface air coolers. Their high over-speed rating is also noteworthy. It is 216 r.p.m. or nearly three times instead of the usual two times normal.

To revert to the steam turbine generator situation, it must not be inferred that the depressed activity in purchases of this type of equipment has adversely affected new development. On the contrary, the decreased activity has given manufacturers more time and opportunity to study and observe the records of machines in service and, thus, to obtain useful information for application to future designs. The question of cooling has received a considerable amount of attention and the success of hydrogen cooling with synchronous condensers has led to its adoption in the case of generators. A new unit, incidentally the world's largest 3600 r.p.m. generating unit which has recently been ordered for the Logan, W. Va., plant of the American Gas and Electric Co., will be hydrogen cooled.

Turbine generator voltages are still standard around 12,000-14,000 v., although in some instances 22,000 v. is being used, as in the new 80,000 kw. generator at Port Washington Station.

In certain instances the operation of brushes and collector rings has been materially improved by providing spiral grooves in the face of the rings. These prevent the development of excessive gas pressure under the brushes. On the larger 3600 r.p.m. generators, commutator trouble developed on the direct con-

[1] p. 586.
[2] Generators for Norris Dam. Electric Journal, June 1935, p. 224.

Generation, Transmission *and* Distribution

nected exciters. The conventional shrink ring type commutator which was satisfactory on small 3600 r.p.m. units was subject to distortion and consequent brush vibration on large 3600 r.p.m. units, especially with high temperatures. Investigation showed that such large commutators should be free to expand both radially and axially and so a rational construction has been developed incorporating this requirement. In all cases satisfactory operating results have been obtained.

The 165,000 kv-a. generator[3] for Richmond Station referred to above was an achievement of considerable importance not only because of its great capacity but on account of its many refinements. This unit was installed in a space originally designed for a unit one-third the size. The main exciter is totally enclosed and its cooling air is supplied from the ventilating system of the main unit. Cooling air is circulated by propeller type blowers which are driven at 3500 r.p.m. by squirrel cage induction motors. Another feature of this unit, though this applies more specifically to the steam end, is that it is one of the first units to be equipped with supervisory instrument protection.

Transmission and Distribution

The outstanding feature of the year's progress in transmission line practice, unquestionably has been the construction of the Boulder Dam-Los Angeles transmission line. With an operating voltage of 275,000 v. and a length of 266 miles, this line marks a new milestone in the history of the transmission of electric power. This line which is the highest voltage and the longest straightway line in the world could not be designed and erected across desert, torrential and mountainous areas without overcoming a host of new problems.

Although it is true that the Boulder Dam line affords splendid evidence of the ability of the engineer to meet present day problems, the general question of electric transmission must take into consideration future possibilities and requirements. The Boulder Dam line has been criticized because of its cost and in some instances the wisdom of the use of 50 and 60 cycle operation for this line has been questioned. Paul M. Lincoln, director of the School of Electrical Engineering at Cornell University, for example, questioned the wisdom of these frequencies in view of the fact that they may limit the capacity of the line when the question of stability is considered. In a letter to the "Electrical World"[4] he pointed out that Prof. Harris Ryan had once suggested the use of a 10 cycle, high voltage busbar, reaching the entire length of California and perhaps extending into Washington and Professor Lincoln suggested that the use of 10 cycles might have been selected for the Boulder Dam line to good advantage. Whether Professor Lincoln's misgivings as to the operation of the Boulder Dam line at 60 cycles are justified or not, his suggestion of a 10 cycle Pacific Coast busbar is of interest. He makes a good case and is sound in his economics for the distance and the magnitude. With the ultimate completion of other large power projects as Bonneville and the Grand Coulee, such a bus might well fit into the picture.

Then there exists the possibility of direct current

[3]The 183,333 kv-a. generator at Richmond Station, Power Plant Engineering, September 1935, p. 508.

[4]May 11, 1935, p. 78.

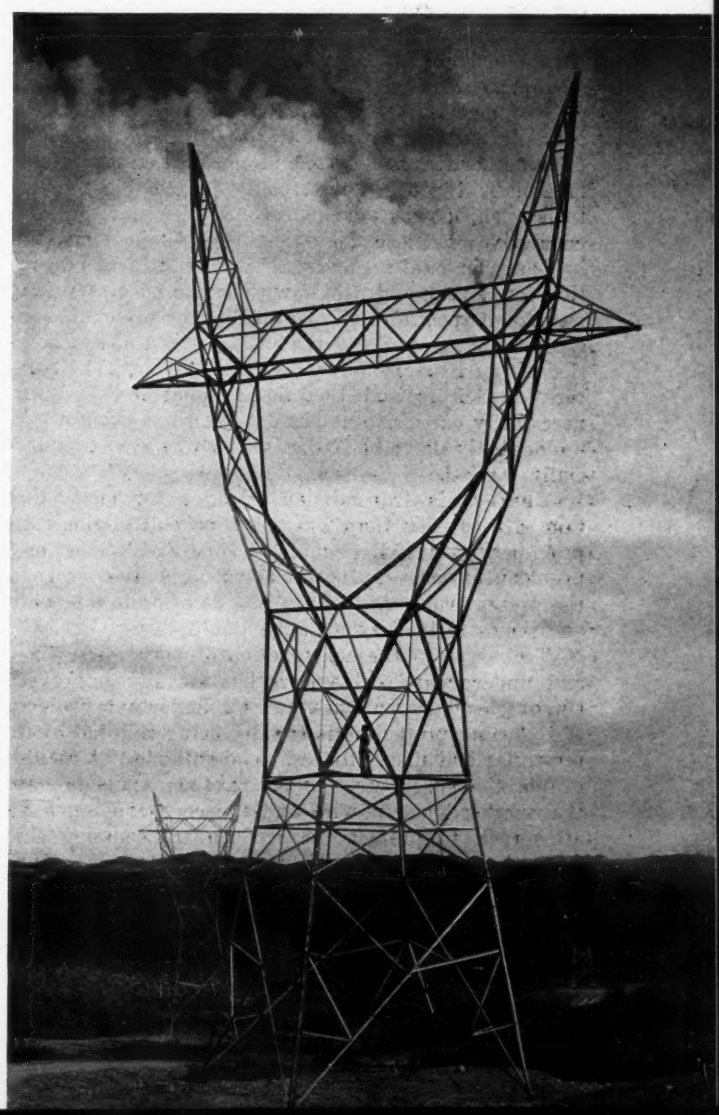


Fig. 2. Boulder Dam Transmission line tower. (Photo, courtesy Bureau of Reclamation)

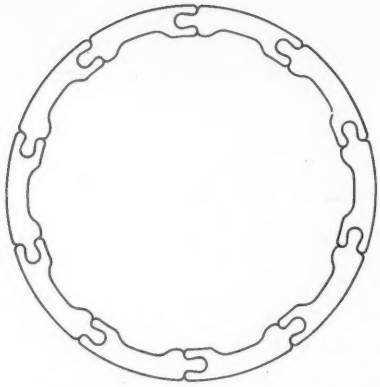


Fig. 3. Cross section of Boulder Dam Cable showing 10 interlocking segments. Diameter 1.4 in.

transmission. One of the highlights of the year's progress was the announcement early in the year of a new system of constant current, high voltage direct current transmission.[5] This system involves the use of hot cathode, grid controlled, vapor-discharge electric tubes, and a 3000 kw. 15,000 v. system of this type has been in operation at the Schenectady plant of the General Electric Co. for over a year. In this installation, 13,800 v. 60 cycle current from the lines of the New York Power & Light Corp. is converted into constant direct current of 200 amp. at 15,000 v. This direct current circuit includes some 15,000 ft. of underground cable. After passing through this cable, the current is inverted from direct back into alternating current and sent back into the 13,800 v. lines of the New York Power & Light Corp.

Whether this new system of constant current transmission will prove commercially practicable remains to be seen but the demonstrations were startling and conclusive and the fact that this semi-commercial, half-experimental set-up has been in continuous operation for a year and a half with entire success speaks well for its possibilities. Naturally, the economic considerations are perhaps the most serious obstacles in the way of its adoption at the present time. The reactors, capacitors and thermionic tubes involved are necessarily expensive at present but these costs would undoubtedly decrease if the system was used commercially.

As regards transmission practice for short distances, those less than 200 miles, present engineering practice it seems is adequate to cope with almost any problem that arises. Insofar as voltages are concerned the present rule of 1000 v. per mile is quite adequate and seems to hold even in the Boulder Dam line.

Technique in the construction of both tower lines and underground cable lines has steadily improved. On overhead tower lines, the all important problem of lightning protection is rapidly being relieved of its mysteries and uncertainties. The cathode ray oscillograph, the surge crest ammeter, the expulsion gap, the overhead groundwire and the counterpoise, have all served to protect the modern transmission line against outages due to lightning disturbances. High speed protective relaying systems, the use of the Peterson coil, more effective circuit breakers, etc., also have contributed to reduce outages both from lightning as well as accidental short circuits and grounds. In a paper presented before the A.I.E.E.[6] Lewis and Foust gave the results of an investigation of lightning effects on transmission lines. These studies confirmed previously reached conclusions as to the effectiveness of overhead and buried ground wires. Direct stroke surge currents of from 2000 to 100,000 amp. were measured in tower structures with the surge crest ammeter and total stoke currents up to 220,000 amp. were indicated. Another interesting fact revealed was that the negative polarity clouds are the source of nearly all direct strokes.

The use of the expulsion protective gap has met with marked success on transmission lines. The first studies of the results of the application of expulsion gaps on 132 kv. lines were presented last year and these showed that these gaps were very effective in preventing flashovers and reducing outages.[7]

More complete and accurate values of the impulse flash-over of suspension insulators and rod gaps have been determined, which facilitate the co-ordination of the insulation strength of the different elements in a transmission system. Another step in advance has been taken in the simplification of the design of counterpoises to reduce line-insulation stresses under lightning surges. It has been shown by application of the multivelocity wave theory that the best overall results are obtained when the counterpoise length in thousands of feet is made approximately equal to one-sixth of the wave-front time in microseconds. This theory shows that the counterpoise behaves as a variable impedance, starting with an initial surge impedance value of about 200 ohms, which decays by an exponential law to its final leakage resistance value in a time in microseconds equal to six times the counterpoise length in thousands of feet.

A marked advance in the multivelocity theory of transmission-line surges has been made by proving that the high-velocity wave, resulting from a voltage surge, is equal to two-thirds of the difference between the main surge itself and the induced surge. The slow wave, is, of course, equal to the difference between the main surge and the fast wave. This simple two-thirds rule applies only when the voltage of the surge is below the corona limit and the transmission-line conductors are completely transposed.

The importance of the high development of high speed relaying as a factor in transmission line practice must not be underestimated. As pointed out, the question of stability of the Boulder Dam line was a limiting one under 60 or 50 cycle operation—it was a serious obstacle but higher speed relaying and quicker circuit breaker action contributed to the escape from this obstacle. On this line, "carrier" is used not only for the relaying but also for supervisory control, communication and calling patrol cars.

With specific reference to the Boulder Dam line, the unusual construction of the conductor used must be mentioned. Due to the extremely high voltage used, the corona loss factor was of primary importance and of course was a determining factor in the size of the conductor. Extensive investigation was

[5]Constant-Current D-C Transmission, Electrical Engineering, Jan. 1935, p. 102. Also Power Plant Engineering, February 1935, p. 126.

[6]Lightning Investigations on Transmission Lines—V, Electrical Engineering, Sept. 1935, p. 934.

[7]Expulsion Protective Gaps on 132 kv. Lines. Electrical Engineering, Jan. 1935, p. 67.

necessary. At the time no corona loss data was available for conductors larger than 1.1 in. in diameter and the data available indicated that the formulas did not give accurate results for such large diameters. Accordingly, tests were made at the Harris Ryan high voltage laboratory at Stanford University from which it developed that a conductor with a diameter of 1.4 in. would be required and that a cross section of 500,000 cir. mils was necessary. A number of different designs of cable were offered but the design selected was a hollow conductor weighing 1.57 lb. per ft. made up of 10 interlocking segments forming a self-supporting tubular structure. A cross section of this conductor is shown in Fig. 3. This cable was formed by specially developed machinery. As a permanent lubrication between segments, graphite is introduced between the surfaces of the interlocking tongue and groove. Special vibration studies were made of this cable leading to the development of special suspension clamps.

The conductors are carried on single and double circuit suspension towers. It was found most economical to use suspension insulators 10 in. in diameter with a hanging distance or pitch of 5 in.; 24 such units constitute a standard suspension string for both the single and double circuit tower sections. The lines are protected by overhead ground wires and by a buried counterpoise composed of ¼ in. diameter, black rolled, copper rod. Such counterpoise arrangements have achieved successful operating results with several power companies and because of the dryness of the soil over which the Boulder Dam line is strung, the counterpoise was deemed necessary. Such counterpoises materially reduce the tower footing impedances and this constitutes one of the important transmission developments of the last few years.

Aside from the Boulder Dam line which incorporates practically every modern feature of high voltage transmission line practice available today, there have been a number of developments which apply to lower voltage lines. Among these the success of the line post insulation is noteworthy. The fundamental idea of the line post insulator was conceived more than four years ago as a result of observations made in the testing laboratories of the Southern California Edison Co. In the course of investigating various insulators and line materials to find some that would not cause radio interference on high voltage lines, a fuse holder of the type shown in Fig. 4 was tried with excellent results. This proved to be the forerunner of the line post insulator shown in Fig. 4. Since that time these have been widely applied to lines as high as 66 kw. with excellent results. They reduce radio interference, save money by increasing ground clearance and reduce cleaning costs.

Another development contributing to the reduction of radio interference from pin insulators is the application of adherent conducting coatings to the central portions of the heads of the insulators and metal thimbles in the pin holes. By extending the coating to cover the entire head and by using a coating of proper resistivity the voltage at which corona occurs can be raised considerably without materially lowering the flashover voltage. This development is still only in the experimental stage but it is an interesting development which gives promise of commercial success.

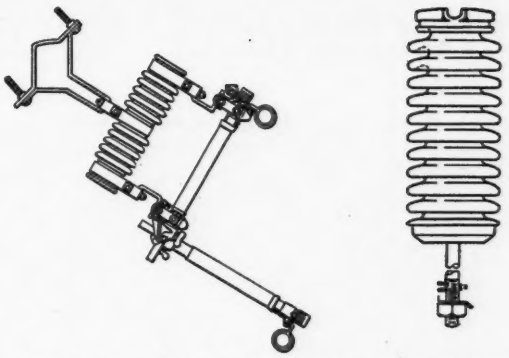


Fig. 4. Fuse holder at the left which finally resulted in the development of the line post insulator at the right

A high strength, high-conductivity, cadmium-copper alloy for overhead lines having the best combination of electrical and mechanical characteristics of any material yet produced was reported during the year.[8] The addition of from 0.8 to 1.0 per cent cadmium to pure copper produces an alloy with a strength of approximately 45 t. per sq. in. and an electrical conductivity of about 85 per cent of that of standard annealed copper.

In the field of paper cable, investigations are being continually made to improve the quality of the insulation and of the lead sheath to reduce losses and to turn out a cable which represents improvement on previous designs even though these designs may have been excellent. During the past year such developments resulted in the compact strand cable and in superdense paper for insulation and further improvements in the hydrogen lead sheath process. The compact strand construction reduces the overall diameter and weight of the completed cable, reduces the a.c. resistance and reduces stress at the conductor surface.

For rural service, a new paper insulated, copper sheathed underground cable was placed in service during the year.[9] This cable is plowed into the ground by a special cable plow, the depth varying from 18 to 24 in. Its simplicity of installation makes it very attractive for rural use and its cost is commensurate with that of overhead lines. It is made for three nominal operating voltages, i.e., 2400, 4800 and 7200 v.

There is considerable activity in the rural line problem largely as a result of the creation of the Rural Electrification Administration by President Roosevelt. The prime essential in rural electrification is a low cost line and much attention is being given the problem. In spending the $100,000,000 appropriated to the REA, line construction will probably be considerably cheapened from that of private utility standards of $1000 to $3000 a mile in an effort to extend the service as widely as possible through farming areas.

In the control of frequency a most interesting development is the use of the quartz crystal oscillator for standard frequency control on the New York Edison system. In this case, the telephone company furnishes 60 cycle standard frequency to Hell Gate Station. This current controlled by a crystal oscillator is received at 4 v. and is amplified to 120 v. for station use.

[8]Electrical Review, March 15, 1935.
[9]New Rural Underground Cable. Electrical World, July 20, 1935, p. 34.

Electrical Conversion, Control

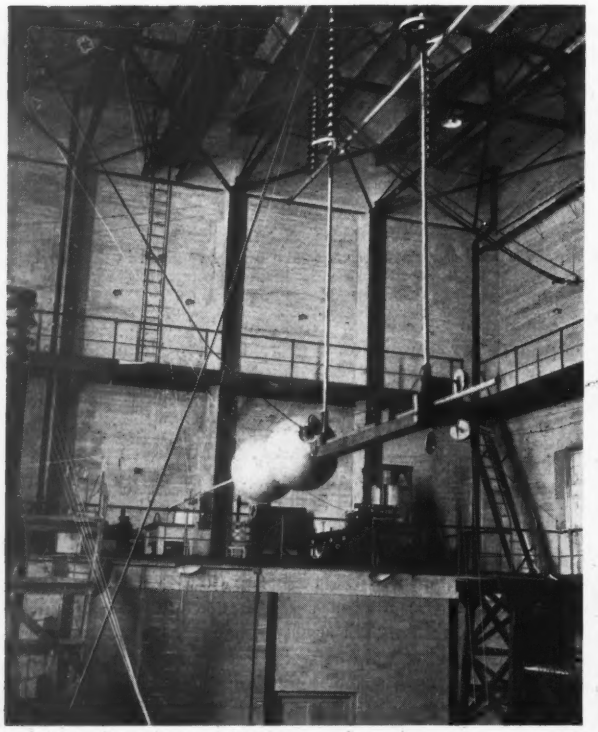


Fig. 1. Sparkless Gap Sphere Voltmeter, developed at the California Institute of Technology, Pasadena.

IN THE FIELD OF conversion apparatus, as in nearly everything connected with the project, the equipment for the Boulder Dam line leads the year's development. The transformers, the synchronous condensers and the switching equipment for this job, in each instance, are the largest in the world. The first units of the transformer installation at Los Angeles were completed and installed. These are rated at 65,000 kv-a. continuously but will take care of emergency loads of 80,000 kv-a. for 2 hr. Measuring 35 ft. high, each unit weighs 116 tons—7 tons of copper, 47 tons of steel, 9 tons of insulation material and 53 tons of oil. Because they were too large to ship in their own tanks, they were thoroughly dried out at the factory, sealed in large tank cars and shipped in an atmosphere of dry nitrogen gas.

The synchronous condensers for this installation also are notable. Two of these were built and shipped. These will be installed at the receiving end of the 287 kv. Boulder Dam line. They are hydrogen cooled, rated at 60,000 kv-a., 13,800 v., 60 cycle and each has a lagging capacity of 36,000 kv-a. This large lagging capacity is needed for voltage regulation of the 270 mile line under lightly loaded conditions. These machines will be automatically started and put on the line upon indication from the main control room.

A new load-ratio-control equipment was designed during the year which is notable especially for its simplicity, compactness and durability. It consists essentially of a dial type, back connected double-arm ratio adjuster with a cam-operated contactor in series with each arm, all mounted on a common insulating panel in a separate oil filled compartment on the main transformer. It is motor operated, suitable for either manual or automatic control.

Pyranol transformers, using the non-flammable, non-explosive insulating liquid have undergone further development. Among this year's applications was an installation of six 3 phase, 500 kv-a., 13,200 v. units of the network type in a new industrial plant.

For use on general distribution systems, a completely self-protecting distribution transformer has been developed. This unit withstands lightning, prevents burnout from short circuits or overload, and has links in the primary winding to protect against feeder outage in the event of internal winding fault. Such transformers are available in capacities from 1½ to 50 kv-a. in standard voltage classes from 2400 to 13,800 v. Improved De-ion gaps furnish lightning protection and an internally mounted breaker in the secondary circuit first gives a visual signal when the transformer's temperature approaches the burnout zone and removes the unit when it is actually in danger.

A current transformer was designed for high-voltage circuits having the advantages of small size and light weight, which makes it possible to mount the transformer readily on the steel frame of outdoor stations, where it can be connected to the bus conveniently.

A cascade potential transformer was designed for use on grounded neutral systems where the transformer is connected from line to neutral. It consists of two or more potential transformer elements, core and coils, connected in cascade.

Following the success in the use of hydrogen cooling with synchronous condensers, this method of cooling this year was applied to a 20,000 kw. outdoor frequency changer set for the Freemansburg Substation of the Pennsylvania Power & Light Co. This resulted in a unit physically smaller than it would have been if conventional cooling methods had been used.

In the conversion of alternating current to direct and vice versa, the thermionic tube has found increasing application, not only for low power work but for high power as exemplified in the 3000 kw. direct current transmission system previously referred to. Another interesting application was that at the Camden plant of the New York Shipbuilding Corporation where a 300 kv-a. static frequency changer was installed in place of an engine driven generating set, to

and Measurement

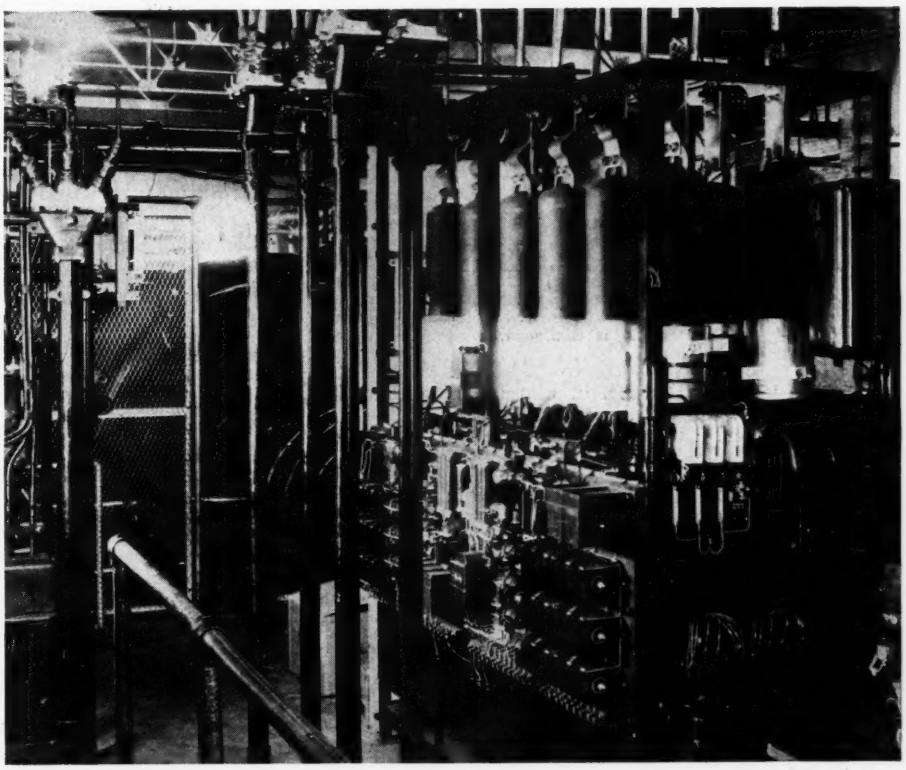


Fig. 2. 300 kw. Static Frequency Converter, converting 3 phase, 60 cycle current to single phase 25 cycle in large industrial plant. (Photo, courtesy General Electric.)

deliver 25 cycle current.[1] This frequency changer comprises 12 grid controlled mercury vapor tubes and converts 2300 v., 3 phase, 60 cycle current into 220 v., 2 phase, 25 5/7 cycle current. The inherent flexibility of the electron tube will enable this same equipment to supply direct current when the 25 cycle current will no longer be needed.

A smaller application of an electron tube converter is that installed at the Suburban Plant of the Scranton Electric Co. Here the entire excitation current for a 15,000 kv-a. synchronous condenser is supplied through a bank of Thyratron tubes. Though this installation was made in 1933, operating data was not released until this year, which shows the installation to be entirely successful. In August of this year (1935), four of the six original tubes were still in service. The other two tubes became faulty after 4000 hr. of operation.

Perhaps one of the most unusual developments in the conversion field is a 150,000 amp. homopolar generator set for an industrial process. This generates the largest flood of direct current yet produced. Specially humidified air is furnished to the 1400 brushes which collect the current from two specially grooved commutators. Driven by a direct connected 514 r.p.m. synchronous motor, the unipolar generator delivers 150,000 amp. at 7½ v.d.c.

Switching and Circuit Breaker Equipment

One of the developments of the depression, not only of the year, has been a vast improvement in circuit breakers both of the air break as well as the oil break type. Not only has the mechanical design been greatly improved as regards classification and standardization, but the improvement in their electrical characteristics has been phenomenal. This improvement has affected the entire range of circuit breaker application and sizes and has its culmination in the great 287,000 v. breakers for the Boulder Dam Lines. Two type of breakers are being furnished for this installation, one incorporating the oil blast principle and the other the De-ion grid principle. Eight of the oil blast units were completed during the year. These, as pointed out in our last year's review, are rated at 2,500,000 kv-a. and use only one-tenth as much oil as a conventional type breaker of equal rating—2500 gal. as compared with 23,000 gal.[2]

In the class of small oil circuit breakers a heavy duty oil blast breaker for switchboard mounting was developed for industrial application. These breakers combine the advantages of long-life contacts and oil-blast construction. They have an interrupting rating of 50,000 kv-a. and are made in two sizes, 600 amp., 15,000 volts, and 1200 amp., 7500 volts. The breakers are double- and triple-pole single-throw with all poles in a welded plate steel tank.

The development of automatic circuit reclosers was carried down to continuous ratings of 8 and 25 amp., 7500 volts, interrupting ratings of 250 and 600 amp., and minimum tripping currents of 25 and 70 amp. respectively. These reclosers are adapted for service on rural lines and light suburban distribution circuits where faults are generally of a transient nature and

[1]Power Plant Engineering, December, 1935, p. 677.

[2]Circuit Breakers for Boulder Dam, Electrical Engineering, April, 1935, p. 366.

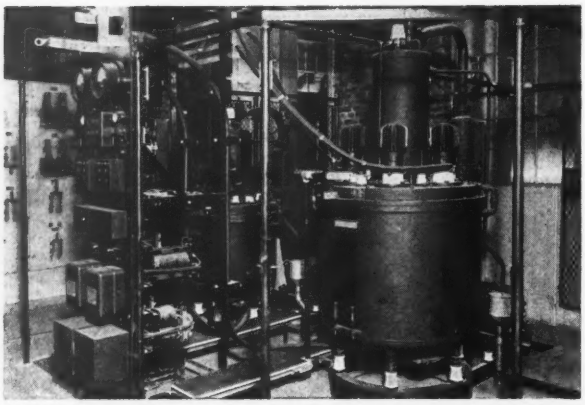


Fig. 3. 150 and 100 kw. 250 v. rectifier sets with semi-automatic control equipment furnishing d.c. power to elevators. (Photo, courtesy, Allis Chalmers)

where the use of oil circuit breakers is not economically justified.

In the application of reclosing breakers a development of interest is the use of the immediate automatic reclosing breaker. Of 614 cases of trouble in one year on primary substation lines of the Alabama Power Co. equipped with such breakers, service was restored instantly 68.5 per cent of the time.

Air circuit breaker equipment has undergone marked changes in recent years and the live front type of apparatus of earlier years has given way to the dead front type of construction. The character of a modern installation is apparent from Fig. 4, which is a view of a recent large board for 600 v. D. C. service. This shows the connections of the bus with the circuit breaker housing.

These breakers are for steel mill service and are of the 2 pole air type with 6000 amp. rating for motors and 8000 amp. for generators. Each is solenoid operated, equipped with magnetic blowouts, rate of current rise trip, in addition to instantaneous overcurrent trip and mechanism arranged for quick opening. All contacts are silver surfaced.

The rate of current rise trip is a notable feature. With several large motors and generators operating in parallel in a system which is closely coupled, electrically, short circuits in steel mills may be as high as several hundred thousand amperes with a rate of rise from 10 to 20 million amp. per sec.

In Fig. 6 is shown the manner in which rate of rise of current is combined with overcurrent as the criterion for tripping. The lower lead of each pole of the circuit breaker is divided into two parallel paths, one of which links with, and thus is the exciting means for, the tripping magnet. This is a path of higher resistance than the other. The other path is made of high inductance by the presence of closely stacked iron laminations. For a steady, unchanging current in the circuit, the total current will divide in this lead according to the conductances of the two parallel paths. For a slowly rising current, substantially the same conditions obtain; thus if the slow growth continues, the circuit breaker will trip at a critical value of total current, according to the calibration. If, however, the current tends to rise with great rapidity, the inductance of the path that does not excite the tripping magnet becomes effective and a greater proportion of the total current is forced through the other (the trip-magnet-exciting) path. Thus the actual value of the total current may be less than the value at which the breaker is set to trip by calibration at steady currents, and the opening of the circuit breaker commences much earlier than if it were necessary to wait for the current to reach the steady current calibrated value.

Aside from developments in breaker mechanisms there has been continued development in switchboard design and construction. One of these is the use of light colored panels for certain installations where the color of the panel is considered in relation to the general lighting system. The main transmitter board of broadcasting station KYW is finished in aluminum and at Richmond Station one of the boiler auxiliary control boards has been made of stainless steel.[3]

Another development is the use of a semi-flush mounted effect that allows better visibility of instruments by providing one plane of view. There have been occasional switchboards in the past with semi-flush-type instruments, but the new design goes much further and utilizes not only instruments but semiflush-type meters, relays, and other devices. This type of semiflush board is made of steel and may be of the benchboard, vertical board, miniature type, or of the cubicle or metal-clad switchgear type.

A new method of wiring utilizing a perforated metal support which was developed some time ago has found increased application this year.[4] This support provides a simple and effective method of making the vertical runs in the back of panel wiring.

Channel buses of copper or aluminum have been developed providing a strong and rigid construction fully able to withstand without distortion the heavy magnetic stresses likely to be encountered in short cir-

[3]Light Colored Switchboards, Electric Journal, June, 1935, p. 221.
[4]General Electric Review, October, 1935, p. 448.

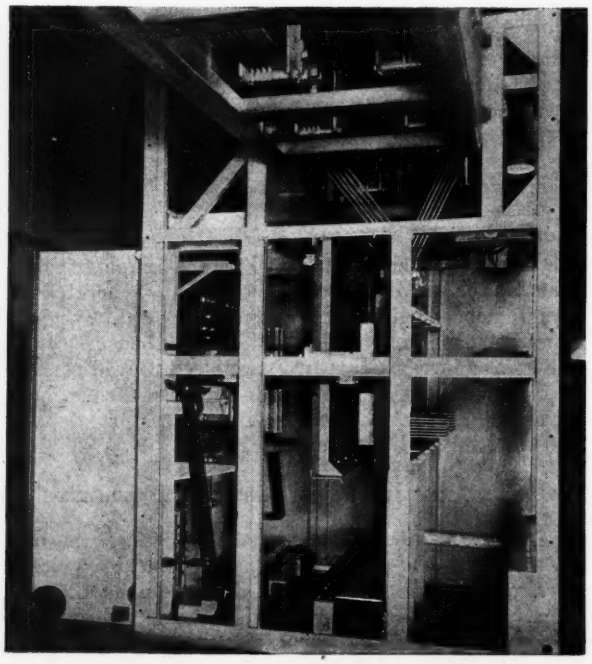


Fig. 4. View of a 600 v. d.c. circuit breaker showing method of connection to bus. (Photo, courtesy I.T.E. Circuit Breaker Co.)

cuits were utilized in the severe duty requirements of steel mill service.

Electrical Control Equipment

In considering the general subject of electrical control, no factor is of greater significance than the increasing application of the electron tube. In every branch of the field, old and new, large and small, the electron tube is imparting new life and vigor and creating new possibilities in that field.

And yet the surface has not been scratched, so to speak. Despite the many applications there has been considerable distrust and hesitancy on the part of the power engineer in using electron devices, first because of the fact that he thought them fragile and unsuited to heavy power and secondly because their use and theory were clothed in the language of the radio engineer which was foreign to the power engineer.

One power system, however, has made considerable progress with electronic devices and has applied them not only in methods of relaying and in communication, but for heavy power purposes. This is the American Gas and Electric Co. In another part of this article we referred to the thyratron system of excitation used on a large synchronous condenser at Scranton. This was one of the first major applications of electron tubes on the American Gas and Electric system. Another that is perhaps even more revolutionary is that involved in the so-called thyratron motor. In this installation a 400 hp. motor is operated and controlled entirely through thyratron tubes. This motor, which operates from an alternating current circuit, has the smooth variable speed torque characteristic of a d.c. motor without any reference to synchronism with the a.c. system.

These, of course, are unusual examples and are in a certain sense experimental but the fact remains that they are in commercial service and except for the economic element are entirely successful. Cost factors in this case as in all commercial applications are dependent upon quantity production and with their increasing use the cost of electronic apparatus will decrease.

In no branch of the industrial electrical field has the application of electronic control devices been more successful than in the electric welding field, that is, in resistance welding control. This year improvements made in thyratron control equipment for spot welding permit wider application of this accurate control. The development of the pool-type thyratron tube which will handle directly primary currents up to 2500 amp. without the necessity of interposing a series transformer, has greatly simplified these control equipments.

Another interesting development in welding control, though it is not electronic, is an arrangement which reduces the open circuit voltage when the operator is not welding or opens the circuit entirely. The control consists of a contactor in the transformer primary circuit which is operated through an auxiliary control circuit carried on insulated conductors embedded in the welding cables to a switch in the electrode holder. This switch is so arranged that the operator when welding naturally holds it closed. When he releases his hold on the handle the switch opens and the transformer is disconnected from the line. Another type of automatic control consists of relays and a primary series reactor so arranged that when the arc

Fig. 5. A high voltage bridge for investigating Corona. By means of this bridge developed at the Oregon State College, important research into the character of A.C. Corona was made.

is broken the primary reactor is automatically inserted in series with the transformer primary, thus reducing the open-circuit secondary voltage to about 30 v.

Considerable attention has been given to the development of small voltage regulators during the year and several new types were placed on the market. Another development was a new automatic synchronizer which provides complete automatic control for generator starting. With this equipment, after pressing a button, the regulator automatically regulates the speed of the prime mover, indicates "fast" and "slow" and phase angles, as does a synchroscope, and automatically closes the circuit breaker at the exact point of synchronism, correctly anticipating for the fraction of a second required for the circuit breaker to close after the control circuit is energized.

For the precise speed control of small d.c. machines an electronic system of control was developed in which an electrically operated tuning fork is the controlling element.[5] This system holds the average speed of a d.c. shunt wound machine as constant as the standard of reference used (and for this the most precise standard known can be used) and holds the instantaneous speed very close to the standard speed if there are no sudden changes of load or applied voltage.

An interesting relay installation was made on the new main line electrification of the Pennsylvania Railroad between Washington and New York. In this service it was necessary that relays be provided that would operate on "zero" volts during times of trouble on the line. So a relay was developed which would "remember" what the voltage was just before the fault occurred. These relays are also able to distinguish between fault currents and magnetizing inrush currents.

Unusual requirements for power protection were met with a new induction cylinder relay having high torque and inherent fast response. The specifications called for an underpower relay capable of operating under full load continuously, set for 12½ per cent load, and to operate in 40 milliseconds at 10 per cent load. Both high-torque and a lightweight moving element were needed to obtain this speed practically at the drop-out point, so that induction-cylinder principle was applied.

A system of angle switching for synchronous motors was developed for use with synchronous motor

[5]Electrical Engineering, March, 1935, p. 307.

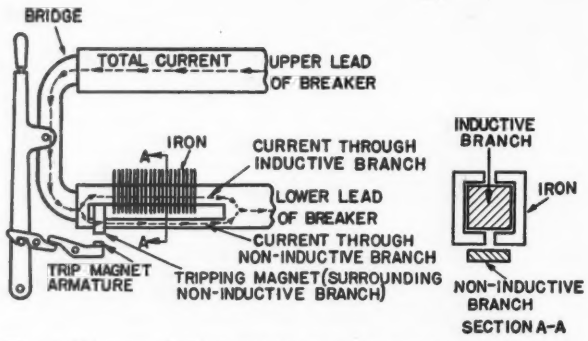


Fig. 6. Diagram showing principles of the rate-of-rise trip mechanism used in circuit breaker mechanism

control of standard type. Ordinarily the time required for the usual relays and contactors to function from any contact device on the shaft of a synchronous motor is too long and too uncertain to precisely time the pull in point.

This difficulty has been overcome by the use of inductive generators on the motor shafts and grid glow type tubes and high speed relays in the field closing circuit. The control functions in the ordinary manner up to the point of applying the excitation voltage. Instead of closing the field contactor at that point, the high speed synchronizing equipment is energized. This in turn applies the excitation to the motor the first time the rotors of the two machines are in the correct angular position relative to each other.

Electrical Measurement

A large number of interesting developments in the field of electrical measurement characterize the year's progress. These cover not only electrical instruments used in the measurement of electrical quantities but also electrical instruments used in measuring non-electrical quantities. As an example of the latter may be mentioned an enamel thickness gage—a small electrical device for measuring the thickness of enamel, paint, or other non-magnetic coatings on steel. This is a tiny device but it does its work more effectively and more quickly than heretofore has been possible by other means.

Among the more unusual measuring devices developed during the year is the sparkless sphere gap voltmeter developed at the California Institute of Technology under the direction of Prof. R. W. Sorensen. With this device sphere gaps are used for measuring very high voltages, not by letting them spark over as has heretofore been the case, but by holding them at a separation greater than spark-over distance and then measuring the force between them. The voltage may then be calculated easily and accurately from well known electrostatic principles. Among the advantages of this type of measurement over spark-over methods are: no corrections are necessary for air temperatures, humidity and pressure; effective voltages are given, measurements are not erratic.

In the measurement of voltage by means of the spark-over method, an interesting development is the use of ultra-violet radiation. Investigations by G. L. Nord[6] show that, especially for smaller gaps and corresponding lower voltages, more accurate voltage measurements result when ultra violet light is directed on the gaps. Photoelectric emission from the surface of the spheres is believed to be the cause of the improved accuracy. Without ultraviolet, variations in the number of free electrons affect the result.

For medium high voltage measurements a new electrostatic voltmeter with a scale up to 18,000 v. was placed on the market this year. The principle features of this voltmeter are, no current consumption, magnetic damping, useful from 150 to 18,000 v. and available in flush, projecting, portable and desk types.

Numerous improvements were made in switchboard instruments and in watthour meters for ordinary commercial power use. During the past few years there has been an increased tendency to use outdoor type watthour meters. During the depression years, though it started long before that, there has been a great increase in current theft throughout and in order to combat this evil, many operating companies have been installing outdoor metering units.

To meet a trend in off-peak rate requirements, a new form of meter was produced which combines in one standard watthour meter element a two-rate register, and an associated transfer mechanism whereby either one or the other set of dials is advanced by the watthour meter, the transfer being made in accordance with a predetermined adjustable time schedule.

The field of oscillography is extremely active and numerous improvements have been made in all types of oscillographs, both of the movable mirror and cathode ray types. Among the latter class, a new high vacuum, hot cathode, high writing speed cathode ray oscillograph which permits recording of surge voltages outside the vacuum is of interest.

At Purdue University, a cathode ray oscillograph for observing two waves was developed under the direction of Prof. R. H. George. This instrument embodies a cathode ray tube of high beam efficiency which makes it possible to use a high frequency oscillator for supplying both the beam and the sweep voltages. An electronic switching circuit makes it possible to portray simultaneously two or more different waves in their proper phase relation, provided both waves have frequencies which are a simple multiple relationship to each other.

For use in the study of lightning, a remarkable instrument is a pre-recording cathode ray oscillograph which virtually anticipates a lightning surge, records it and saves the record for future study. These instruments applied to transmission lines will "watch" for

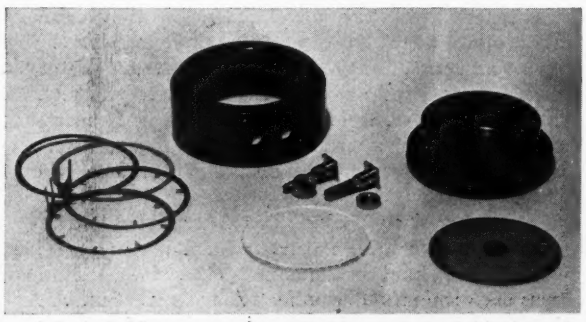


Fig. 7. The Photronic cell is involved in many applications. (Photo, courtesy Weston Electrical Instrument Co.)

[6]Effect of Utraviolet on Breakdown Voltage, Electrical Engineering, September, 1935.

weeks or months, so to speak, in an inactive state, yet will instantly come into action when a lightning surge occurs and record it. The way in which this is accomplished is simple yet highly effective. Dr. A. W. Hall in describing it at a meeting of the National Academy of Science, referred to it as "an oscillograph with memory." As its name indicates, it uses memory as a substitute for foreknowledge. One makes sure that it does not miss the event by the simple ruse of putting it on the job long enough ahead of time—hours or months—with instructions to record continuously on its tiny slate and erasing as fast as it writes. When at length the important event occurs, a Thyratron tube acts to open a camera shutter and takes a picture. The pencil which does the recording, is, of course, the cathode ray. The slate is a glass plate covered with a thin coating of willemite, a phosphorescent mineral which glows brilliantly when the cathode ray falls on it and continues to glow for about a twenty-fifth of a second afterwards. "That," said Dr. Hall, "is the memory."

No applications of this remarkable instrument have been made on transmission lines but it is being used in studying the life of electronic rectifiers. The times when the rectifiers will fail are quite unknown but this device is sure to be on hand to record the happening.

In order to facilitate the study of welding operations, a cycle recorder has been developed to give a permanent record of the number of cycles during which the welding current flows. In this recorder a polarized reed is made to deflect when energized by the driving coil surrounding the reed. By means of a system of inkless recording, a record is produced on a thin paper tape which may be filed away for future reference if desired.

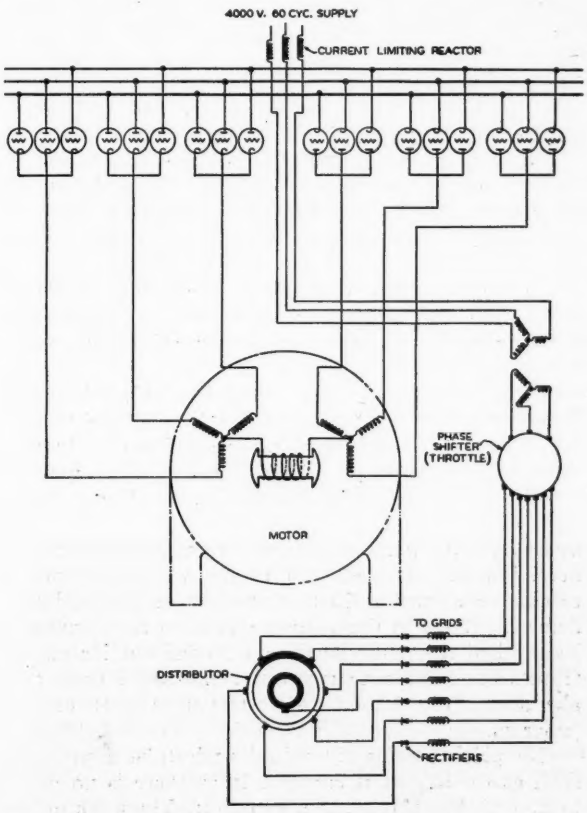


Fig. 8. An important event of the year was the installation of a 400 hp. Thyratron motor. This is a simplified diagram of the connections of this motor, showing the position of the Thyratron tubes.

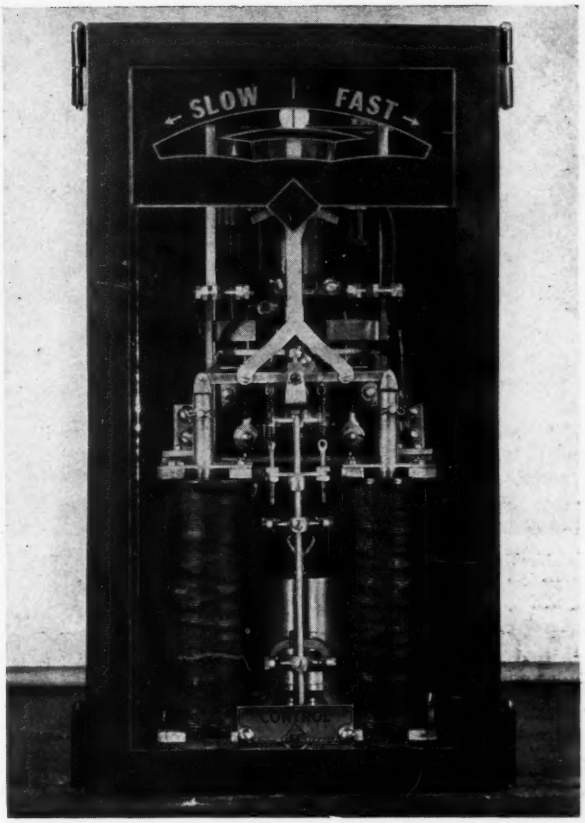


Fig. 9. Automatic synchronizer which entirely removes the human element in synchronizing. (Photo, courtesy Allis Chalmers.)

For use in a wide variety of speed measurements a new stroboscopic tachometer is now available. This provides accurate speed measurement without the necessity for mechanical contact with the machine under study. The device is portable and completely self contained; lamp, triggering oscillator and controls all being in a single case. It operates direct from 115 v. circuits.

Just a Few More New Ones

Other instruments brought out during the year are: "A symmetrical-compound meter; a portable wave analyzer; a photoelectric spectrophotometer which automatically plots in graphic form, the spectral reflection and transmission data for a variety of materials; a new magnetic testing set for both research and commercial testing; an iron detector for inspection and protective purposse during manufacture; an electronic timer, which accurately measures time intervals in terms of thousands of a second. The measurement and analysis of "noise" is becoming more and more important in engineering work and there has been steady progress in the development of noise meters. In illumination work, photo-electric devices have practically superseded all forms of comparison photometers. All types of photoelectric devices in this field have undergone improvement.

Bonneville Project on the Columbia River

Federal Projects Stimulate

AS POINTED OUT in an address by Dr. C. F. Hirshfeld recently, it was not so very long ago that many people believed that hydraulic engineering had about reached its maximum of achievement. The almost stationary maximum efficiencies and the huge capacities of single units were taken to justify such a conclusion. But, as Dr. Hirshfeld went on, once more the restless and ever progressing spirit of man was overlooked. Not only has there been remarkable and continual development in the hydraulic field during the past few years but even more startling progress lies ahead.

Government Hydraulic Projects

One factor of enormous importance in this development of hydraulic equipment, of course, has been the increase in constructional activity—the many great government projects. There has been much criticism of these government projects from various quarters but whatever one might think of their social or economic significance, certainly their technical aspects are above reproach. From an engineering standpoint these projects—Boulder Dam, the Columbia River projects, the Tennessee Valley developments—are among the world's greatest achievements.

Before we review the progress made on the construction of these Federal Power projects, we will consider, briefly, their general significance, for if a proper understanding of these projects is to be had, their general and social significance is quite as important as are their technical features. There is much loose and unintelligent thinking about these matters and many conclusions drawn which are anything but the results of reason. This is especially true with regard to electric power development. In nearly all instances electric power generation is not the primary reason these projects are being constructed. In most cases power generation is only incidental to the much greater problem of flood control, land reclamation, and water storage for irrigation. And in many cases, these problems are not new. Boulder Dam is not a recent conception; indeed, it goes back as far as 1902 when President Theodore Roosevelt signed the Reclamation Act and when investigations for the control of the Colorado River were started. It was Arthur P. Davis who in 1918 conceived the project for a dam of unprecedented height in Boulder or Black Canyon. The dam is a vital necessity whether power is generated or not, and with its completion, the residents of the Imperial Valley can breath a sigh of relief for it removes for all time the menace of the Colorado in its rampant moods.

In the Tennessee Valley, also, the first part of the T.V.A. job is to put the water resources of the region under control. The Tennessee River is a potential waterway. By building dams on its tributaries, assistance can be given to flood control of the Ohio and Mississippi Rivers. At the same time, these works, useful for navigation, can develop and engender millions of horsepower of electrical energy. The plan to reclaim or resuscitate millions of acres of destroyed land and the unified plan to control soil erosion is apart from the immediate subjects under consideration here, but they are all part of the work and should receive consideration in any analysis of the merits or demerits of the project. In earlier days the Tennessee Valley had the finest hardwood forests outside of the tropics but lumbering interests slaughtered them and abandoned the land. Reforestation is part of the program.

No private company would undertake a program such as the T.V.A. is engaged in as there is no profit in it. Only the Government can do it. The work of the T.V.A. is simply the application of scientific knowledge and resources to a problem that is as old as civilization itself.

Hydro-electric Development

Ever since Wilson Dam at Muscle Shoals was built during the war, its "economics" have been questioned, particularly with respect to the wide variation in the availability of power. When the Tennessee River is high, during the winter, there is water enough to develop 300,000 hp. or more, but in the driest summer seasons there is water for only 50,000 hp. The work of the T.V.A. will correct this.

Two hundred miles upstream from Muscle Shoals on the Clinch River, the Norris Dam is being built. This dam will create a storage reservoir great enough to store almost a year's rainfall. During the winter when the river is high and power abundant at Muscle Shoals, this Norris Dam plant will be shut down and the water stored in the reservoir. During the summer when the river is low and power scarce, Norris Power Plant will be operated. The water, however, will flow down to Muscle Shoals where it will again be used for power generation. The two plants operated as a single system will generate five or six times as much dependable power as either one alone. Norris Dam is now 90 per cent completed.

About 15 miles upstream from Muscle Shoals, another dam is being built, the Wheeler Dam. This dam will provide a reservoir about 100 sq. miles in area and provide a navigable channel for 80 miles to Guntersville, Ala.

A third dam is being built below Muscle Shoals at Pickwick Landing which will form a lake 76 sq. miles in area backing up to the foot of Wilson dam at Muscle Shoals.

All of these projects are well under way. Norris, as was stated, is 90 per cent completed and the two 56,000 kv-a. generating units will go into operation in 1936. Work on Wheeler Dam also is up to schedule. The first of 60 huge steel flood gates have been delivered and the first 45,000 hp. turbine is being erected and contract for the second unit has been awarded. Eventually there will be 10 such generators, a total of 450,000 hp. At Pickwick Landing, the first cofferdam has been unwatered and excavation work is under way. While this dam is not needed for power production, it is being so constructed that the power installation can be made when needed. Plans here call for 6 units of 45,000 hp. each.

In considering these various plants, it should be kept in mind that the mere construction of Norris Dam will at least double the prime power of every plant below it. And there are to be 8 dams below Norris.

It is scarcely necessary to recount the progress at Boulder Dam. This job is approximately 2 years ahead of schedule. The dam has been completed and the first water was turned into it on February 1. Since then work on the power house has been progressing rapidly and the first units are being delivered. The initial installation comprises four 82,500 kv-a. units and one 40,000 kv-a. unit. The initial installation, it is expected, will be completed this year. Two additional 82,500 kv-a. units will be ready for operation about January 1, 1938.

Both of the Columbia River Projects are well along in construction. At Grand Coulee, which is being carried out by the Department of Reclamation, a construction city of some 5000 persons is fully established and excavation work is in progress. At Bonneville, where the work is being done under the direction of the War Department, the cofferdam has been completed across half of the river and concrete on the actual dam is being poured. The spillway is practically completed and construction of the canal is far along. The accompanying photographs show the extent of development on these projects.

Another of the great government projects under construction is that at Ft. Peck on the Missouri River in Montana. Though one of the least known, it is one of the largest. When completed it will be by far the

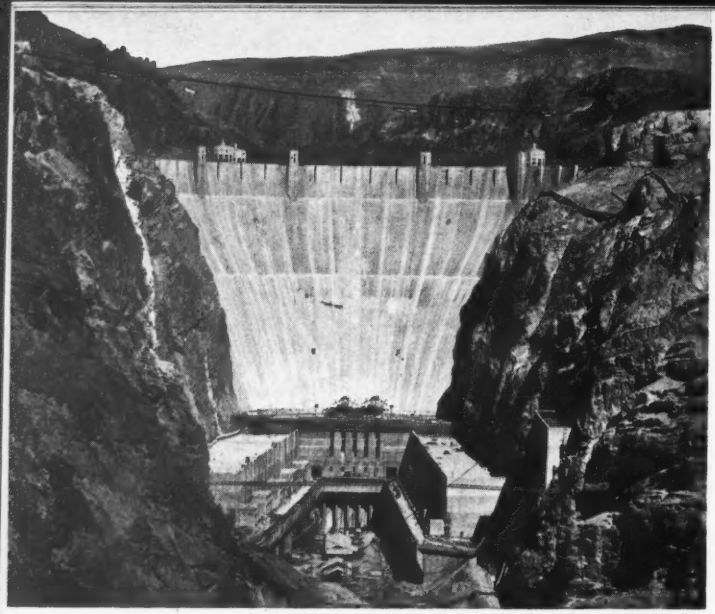


Fig. 2. Downstream face of Boulder Dam (Photo, courtesy Bureau of Reclamation)

world's largest earth filled dam; its 90 million cubic yards is more than eight times the volume of Saluda Dam, the present record holder. At present no power development is planned, the dam being primarily for river flow control, but some 12,000 kw. of primary power is available.

The Casper-Alcova project in Wyoming involves irrigation, power development and river regulation. This includes the Seminoe Dam and power plant and the Alcova diversion dam, both of which are under construction. At the Seminoe Dam a three unit power plant is to be built with a total capacity of 50,000 hp.

Finally, among the large government projects, is the Passamaquoddy Tidal Power Project near Eastport, Maine. An allotment of $10,000,000 was made for the first year's development of the project and actual work was started July 1. The initial development will embrace a series of earth-fill, rock-armored dams and rock-fill dams, the main tidal power house, the emptying-gate structure, and lock. The dams will range from 30 to 150 ft. in height and up to nearly 4000 ft. in length. The power house will be built to provide for 22 units, only 10 of which will be installed initially. The units tentatively proposed are to be of 16,667 kv-a. capacity designed for heads varying from 5 to 25 ft.

The pumped storage development at Haycock Harbor which is part of the Passamaquoddy project, will consist of a large pumping installation of 180,000 hp. capacity and a power plant of 44,800 kw. capacity together with the necessary dams and levees to create a reservoir at elevation 120 to 130 ft. for pumped storage.

Another federal project which may ultimately involve power generation but which is planned only for navigation and flood control is that near Grafton, W. Va. This is under construction.

Among the non-federal projects, those of the Kanawha Valley Power Co., referred to below, are of interest and also one of the Electro-Metallurgical Co. of Glen Ferris, W. Va. This company is constructing a large hydroelectric project on the New River between Hawk's Nest and Gauley Junction, W. Va. The gross head will be 163 feet with an initial installation of 140,000 hp. in four units of equal capacity. The ultimate installation will be for 175,000 hp.

Two 1430 hp. Kaplan turbines have recently been installed at the plant of the Chemical Paper Mfg. Co. at Holyoke, Mass.

Technical Development

Among the technical developments in the hydraulic field, without question the most important is the development of a new, adjustable blade turbine to be installed at the Marmet plant of the Kanawha Valley Electric Co. Two interesting hydraulic developments are under construction in West Virginia by this company which is a subsidiary of the American Gas and Electric Co. Both projects are on the Kanawha River, the first at Marmet about 10 miles and the second at London, about 25 miles upstream from Charleston. This company also has recently applied for a license for a new hydroelectric plant at the Winfield Dam now under construction on the Kanawha River, 3 miles below Winfield, W. Va. Here they propose to install 26,000 hp. in 4 units of 6500 hp. each.

Automatic Adjustable Blade Turbine

The adjustable blade turbines for the Marmet Plant are being built with an experimental runner of an automatically adjustable type of new design. The vanes on this runner are similar to those of the Kaplan turbine except that in this case they are automatically adjusted entirely by the flow of the water through the turbine.

Not so very long ago, many people believed that hydraulic engineering had about reached its maximum of achievement. The almost stationary maximum efficiencies and the huge capacities of single units were taken to justify such a conclusion. But, as Dr. C. F. Hirshfeld pointed out not long ago, once more the restless and ever progressing spirit of man was overlooked. Not only has there been remarkable and continual improvement in the hydraulic field during the past few years but even more startling progress lies ahead. The great government projects now under way have greatly stimulated interest in hydraulics and are representative of the world's greatest engineering achievements.

The runner vanes are pivoted on roller bearings and connected through gears and racks to a dashpot in the runner. Each vane is pivoted slightly above the center of pressure so that the water flow creates an hydraulic moment which tends at all times to open and increase the pitch of the vanes. This moment is opposed by a device which creates a reactive moment that tends at all times to close or decrease the pitch of the vanes.

There is a maximum efficiency position of the vanes corresponding with the speed, head and load under which the turbine is operating. Experiments have demonstrated that if the runner vanes are properly pro-

portioned and pivoted, the reactive moment required to maintain the best efficiency for a given installation will be practically constant within the usual variations of head and load. The runner has an inherent tendency toward self governing.

Another interesting feature of the runner is that the vanes open wide when the turbine is started and this gives maximum starting torque. As the turbine approaches normal speed with no load on the unit, the vanes move to the closed position after which they move to the position required by the load.

Venting Turbine Casings

Some years ago it was discovered that the output of hydraulic turbines at small gate openings could be increased by admitting air into the turbine casing. Since this was first noticed investigations have been

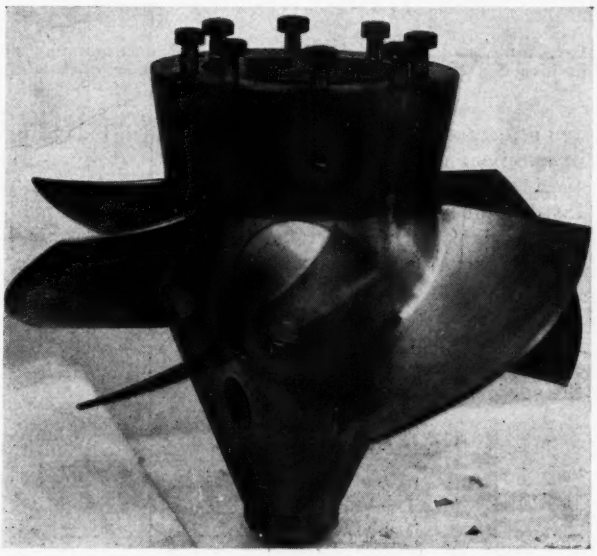


Fig. 3. Laboratory model about 1/12 the size of the Marmet runner. (Photo, courtesy Newport News.)

continued and it has been shown that efficiency increases ranging up to 30 per cent or more result from venting in this manner. A number of tests were made at the low head plant of the Illinois Northern Utilities Co. at Dixon, Ill. In this case the head covers of the turbine were equipped with four openings, each tapped for 2½ in. diameter pipe and normally sealed with standard pipe plugs. The first test was made by closing the turbine gate to 0.35 at which point the output of the generator was practically zero. One plug was removed and the power output became 55 kw. With two plugs removed the power dropped to 28 kw. and with three plugs out the power was 22 kw.

In discussing this question of venting, the use of air with hydraulic turbines in another connection is of interest. Several recent studies of pitting, vibration and operating economy in hydro plants point to air as a useful element for use with water. Cavitation is less in winter than it is in summer and the apparent reason is that there is more dissolved air in the water during the winter. It is possible that a combination of temperature and air best explains this effect but tests show that the introduction of air into water decreases cavitation. A further use for air has been found in one plant where air is introduced through the head cover when operating at maximum output with a great decrease in vibration. Though further research is needed, it seems quite evident that air is a valuable commodity for use with hydro work.

Cavitation Research

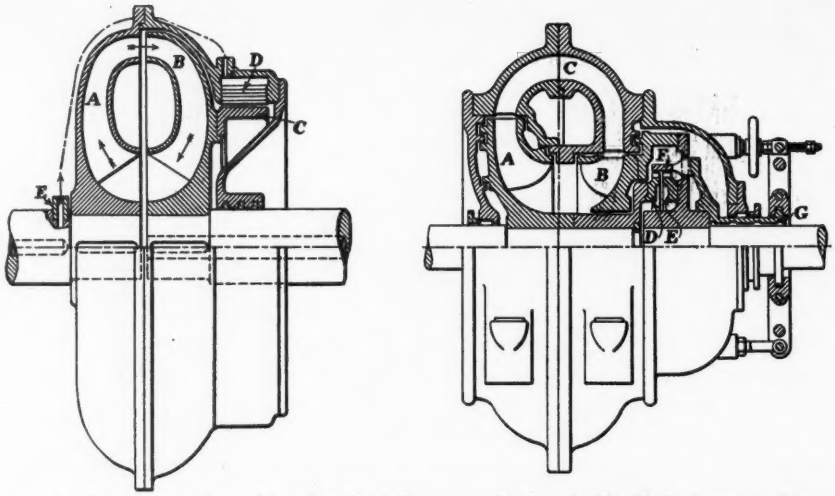
It is impossible to describe in detail the very thorough investigations that have been and still are in progress. The work at Massachusetts Institute of Technology has brought out some interesting results which seem to corroborate the theory as enunciated by Prof. Spannhake that cavitation is the result of a mechanical action.

In certain of these tests plate glass and lead plates were damaged without loss of weight. A lead tube fixed in a hole in the pipe near the region of vapor collapse burst near the outer and sealed end, regardless of the length of the tube, as if by water hammer. The damage to glass or other metal boundary material took place only opposite the region of vapor collapse. The appearance of such materials, after short exposure, is such as would be caused by inaccurate shots at a target. At first a few scattered hits are recorded but eventually a closely defined area is thoroughly peppered. The work being carried out at M. I. T. is of particular interest because of the use of Dr. Edgerton's high speed motion picture equipment and Prof. R. D. Ray's sound recorder. Prof. C. F. Taylor, by means of his automatic indicators, made it possible to reveal the periodic nature of cavitation even though one cycle takes place within a fraction of a second, and to correlate the frequency of the emitted sound and shock with that of the photographic record.

Hydraulic Couplings

In Europe there has been considerable development in connection with couplings and coupling arrangements for pump storage plants. When pump storage plants were first developed, pumps driven by separate electric motors were provided, but more recently it has become the practice to set the pump in line with and arranged so that it can be driven from the main generating set. This requires the use of suitable coupling

Fig. 3. Recent view of Grand Coulee (Photo, courtesy Bureau of Reclamation)



Figs. 5 and 6. Cross-sections showing principle of hydraulic coupling

Referring to the arrangement illustrated in Fig. 5, the hydraulic clutch with its impeller A and turbine rotor B, is shown at the left hand side.

A drum C attached to the rotor is acted on by a series of friction shoes actuated by pistons D, the cylinders of which are supplied with pressure water, by way of a connection E, from a passage through the center of the driving shaft. It is permissible to allow a slip of from 10 per cent to 15 per cent on the hydraulic clutch, which may consequently be made comparatively small. A slip of this order still allows the friction clutch to be thrown in without serious wear on the friction blocks. As the main drive is transmitted through the friction clutch, the operation of which depends on an outside supply of pressure water, the arrangement is not self-contained, and in order to eliminate dependence on an outside source of power, Messrs. Escher Wyss have introduced a transmission of this kind, incorporating a positive dog clutch. This is illustrated in Fig. 6 at the right.

devices. Friction clutches, direct and electromagnetically operated have been used for this purpose in capacities as high as 10,000 hp., but these have not proved entirely satisfactory so attention has been turned to the hydraulic clutches of the type first introduced nearly 30 yr. ago by Fottinger for marine use. Recently some interesting hydraulic clutches of this type were constructed. The largest, so far manufactured, are the four 30,000 hp. units for the Waldeck power station. In practice the throwing in of one of these couplings from the beginning of the filing of the casing, takes about ¾ of a minute.

Steel Dams

With regard to the turbines for the government projects, many of these units are not only of record breaking size but represent great improvement over previous practice in many respects, including better provisions for maintenance. The 115,000 hp. turbines for Boulder Dam are the largest in the world. The 45,000 hp. turbine being installed at Wheeler Dam is of the fixed blade propeller type and is the most powerful of its kind in the world. Some of the later units at this project it is expected will be of the Kaplan type. The Kaplan type turbine is finding increasing favor, particularly in plants required to run under very wide variations of dischrage. Turbines of this type and of larger size and greater capacities than heretofore constructed will be installed at the Bonneville plant on the Columbia.

Use of Steel for Dam Construction Proposed

A question of considerable importance was discussed recently at a meeting of the American Institute of Steel Construction. This involved the possible use of steel dams. As pointed out by Dr. Otis Hovey, New York consulting engineer, the use of steel as a suitable and economical material for the construction of fixed dams has received little attention. It has been used freely and satisfactorily for movable dams of all types for many years, but has been almost entirely ignored in connection with fixed dams. Long ago a few fixed steel dams were built which today are in excellent condition.

As a consequence of this discussion, the American Institute of Steel Construction has prepared a manual on steel dams for engineers as a guide in the practical construction of steel dams. This Manual gives a general discussion of the theory and design of steel dams, descriptions of steel dams, fill dams with steel core plates, fill dams with steel face plates, dams with steel sheet piling cut-offs, and a complete bibliography of the subject.

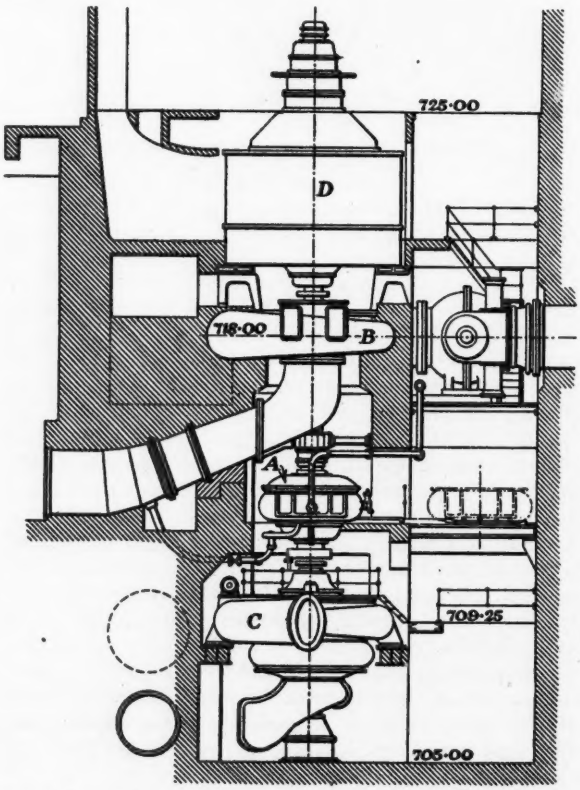


Fig. 7. Cross section of one of the two 27,000 hp. units at the Schluchsee Station

Electrical Research

"RESEARCH" CONTINUES to be a very much abused and over-used word. Much of what is called research these days is a travesty on scientific method—a degradation of science. In the electrical field, however, research really possesses scientific significance. It is not only the foundation upon which practically the entire industry is built, but each year research continues to point the way to new achievements, and to fresh starting points. In the electrical industry we have "pure" research at its best. Many of the things in daily use have their origin in the purest kind of research; the modern incandescent lamp, the telephone, radio equipment of all kinds, etc. Research has brought the electrical industry a long way—it has made it one of the most dominant factors in our entire civilization. Yet, nobody dares to say what electricity may do in the future. As Dr. Whitney of the General Electric Research Laboratory has said, "Discoveries and inventions are not terminals; they are merely starting points."

Electrical research as a subject is a large order. In this article we can present only a general picture of what the field involves. While in some instances details will be discussed, these details must be considered as merely typical of groups of developments.

Of greatest importance in the field of electrical research are the fundamental investigations being made into the nature of electricity and the structure of matter—the continued development of quantum mechanics. A few years back, we had only the proton and the electron to deal with in our theories of electricity. Today, as a consequence of theoretical and experimental investigations in laboratories all over the world, we have a host of new entities; the positron and negatron, the neutron, the deuton, etc. Whether these new entities, or conceptions, whatever they may be, will affect the future course of the industry, nobody can say, but if the results of our knowledge of the electron may be regarded as a criterion, it would be extremely unwise to predict their effect to be negative.

An extremely important consequence of our new knowledge of the electrical properties of the atom is its effect upon chemistry. Continued progress in the field is rapidly revolutionizing our ideas in chemistry.[1] Articles on the quantum[2] theory have recently been published which help to consolidate this new knowledge and make it available for the chemist and metallurgist to use. It is realized that such practical questions as the adhesive power of dissimilar molecules and the increased emission of electrons from tungsten when covered by a monatomic film of thorium are dependent on the quantum theory of electric penetration through potential barriers on the one hand, and the theory of surface chemistry on the other. These new theories suggest that important discoveries of materials with new mechanical properties will follow the application of modern physics and chemistry to practical problems.

[1]Mechanical Properties of Matter. By I. Langmuir, Mechanical Engineering, Aug. 1935, p. 486.
[2]Elements of the Quantum Theory. By S. Dushman, Journal of Chemical Education, May, June and July, 1935.

Fundamental studies of high-current arc phenomena have been undertaken, paralleling the basic investigations of vacuum-tube phenomena that have been carried out in the past. A method of determining the temperature of an arc from sound-velocity measurements has been developed,[3] and the temperature of the copper arc has been found to be 4200 to 4000 deg. F. for a six-ampere arc with a length between three and 13 cm.[4] The instability of metal arcs has been investigated, and it has been found that highly polished electrodes produce much more stable arcs, the amount of metallic vapor in the arc varying greatly with the electrode surface condition.[5]

In the Electrical Industry we have "pure" research at its best. Many of the things in daily use owe their origin to scientific research. The modern incandescent lamp, transcontinental telephony, picture transmission, had their beginnings in the purest kind of research. It was Langmuir's intense personal interest in the action of rare gases that resulted finally in the incandescent lamp of today and in the modern vacuum tube.

During the past year as in previous years research has been a dominant factor in every branch of the electrical field. It has produced everything from 3000 kw. direct current transmission systems to magnets that lift sixty times their own weight; from metal vacuum tubes to new kinds of flowers and plants. Many of these developments are far outside of the "power" field but all of them are connected with the power field through the medium of the electric generator.

The electrical properties of many vapor and monatomic gases have been studied, such questions as the current capacity of low-pressure mercury-vapor arcs being given special attention.[6] It has been found that when more than 50 per cent of the mercury atoms in an arc stream are ionized, any further increase in current causes a very abrupt rise in voltage, thus setting a limit on the permissible current density, dependent on the vapor pressure.

Studies in surface chemistry have been continued, especially in regard to the laws governing the formation of oil films on liquid and solid surfaces. The main interest in these results is that they make it clear that

[3]The Determination of Arc Temperature from Sound Velocity Measurements. By C. G. Suits and H. Poritsky, Physics, June, 1935.
[4]The Temperature of the Copper Arc. By C. G. Suits, Proceedings National Academy of Sciences, January, 1935.
[5]Stabilizing Arcs by Electrode Surfacing. By C. G. Suits, Physics, December, 1934.
[6]Fundamental Electrical Properties of Mercury Vapor and Monatomic Gases. By A. W. Hull, Electrical Engineering, November, 1934.

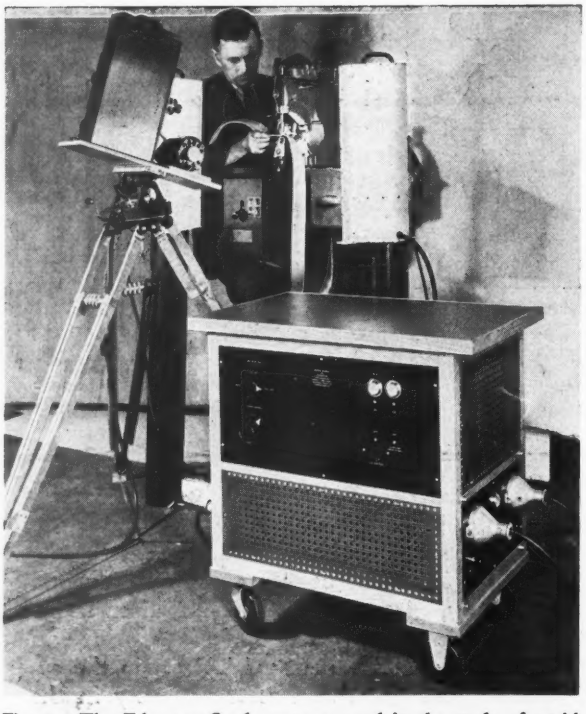


Fig. 1. The Edgerton Stroboscope as used in the study of rapid mechanical motion. (Photo, courtesy General Radio Co.)

we have a real two-dimensional world at the interface between oil and water, which is almost completely analogous to the three-dimensional world with which we are familiar.[7] Methods of measuring oil film thicknesses by control of the oil oxidation and the use of interference colors have been developed.[8] Further development of earlier described methods of building up successive monomolecular layers of stearic acid on glass has enabled films up to 200 accurately counted layers to be formed.

Continued experiments with artificially induced fevers and high-frequency heating of local areas of the body have been carried on in the hope of relieving human ills. A recent development has been the treatment of stiff shoulder joints, or bursitis, by inductive heating of the affected area. It seems that the trouble is due to deposits of lime between the muscles, which often follows an injury or severe exercise, and that the heating facilitates the natural solution or reabsorption of the deposit.[9] This new-found ability to create high temperatures in designated local areas inside the body thus promises to be increasingly useful to physicians.

Another interesting aid to the physician is a new method for the measurement of skin temperatures,[10] which is particularly useful in gauging the adequacy of the blood supply to the extremities of persons having various diseases.

Experiments have been continued with X-ray exposures of seeds. A series of citrus fruit seeds were treated with X-rays and the variants have been cultivated in a greenhouse for a full year.

Systematic determination of the X-ray exposure limits within which mature pollen grains and mold spores survive was undertaken, and the effects of a variety of types of ray were observed. It was found that six times more energy of hard than soft X-rays is required to kill pollen, but only twice as much is permissible for mold spores.

An important development in the field of applied mathematics and of great interest to electrical machine designers is the recent development of the generalized Tensor theory of rotating electrical machinery. This is providing a unified set of equations and concepts from which the performance of different machines can be determined.

One of the fundamental concepts developed by this method is that any change in the connections between windings of an electrical machine, or between the elements of stationary networks, is mathematically equivalent to a transformation of co-ordinates, with the total-circuit power input as an invariant. The discovery of one invarient drew immediate attention to the existence of other invarients, and it has since developed that a complete physical analysis and the performance calculations of all rotating machines require only a single set of equations, valid for all axes of all machines. From this one set of equations the performance of a machine is found by a routine procedure.

The manipulation of Tensor equations and the procedure of getting a numerical answer from them are even simpler than in ordinary Vector analysis. The greatest difficulty in their study is that Tensor Analysis has always been concerned with either the abstract speculations of relativity dynamics, or the differential geometry of curved spaces, both of which are beyond the sphere of the practical engineer. A presentation of the Tensor theory of rotating electrical machinery,[11] began in 1935, puts the abstract mathematics of the space-time physicists into engineering use, and so is creating a fresh interchange of ideas between engineers, mathematicians, and physicists generally.

Research in "electronics" continues to yield amazing discoveries and continued new and possible new applications each day. This field is so vast and so all inclusive that we can present only a few of the more important aspects of it here.

Perhaps the most important development of the year was the commercial introduction of the all metal vacuum tube. The metal tube has been made possible by two major developments; first, the new iron-nickel-cobalt alloy called Fermio which has the same thermal expansion curve as that of the special glass used in modern vacuum tubes, and second, the high speed Thyratron type control of welding. In the production of these tubes a current of 50,000 to 60,000 amp. is allowed to flow across the contact surface of 0.02 to 0.05 sec., the time being accurately controlled by an electronic timer to suit the thickness of the metal being welded. The instant the adjacent metals become plastic, they are forged together, completing the weld so quickly that the heat is confined to the projection, and the tubes can be immediately lifted from the electrodes and handled with bare hands.

[7]Surface Chemistry. By I. Langmuir, General Electric Review, September, 1935.
[8]Interference Colors in Oil Films on Water. By K. B. Blodgett, Journal Optical Society of America, December, 1934.
[9]Bursitis-X-Rays-High Frequency. By W. R. Whitney, General Electric Review, February, 1935.
[10]Resistance Temperature Meter for the Measurement of Skin Temperatures. By F. S. Marcellus and H. L. Grice, General Electric Review, December, 1934.
[11]The Application of Tensors to the Analysis of Rotating Electrical Machinery. By Gabriel Kron, General Electric Review, April through December, 1935.

Two new types of thermionic cathodes have been under investigation. The first is a thoria-coated tungsten filament, similar in many respects to the familiar oxide coated nickel filaments but with a much higher operating temperature. The second type is called a migration cathode and is expected to increase the life of hot cathode gas filled tubes. It consists of a hollow enclosure with metal walls perforated with very fine holes, too small for discharges to pass through but permeable to barium or thorium. A mass of granular barium or thorium oxide in the annular space surrounding these walls furnishes an inexhaustible supply of such atoms. Preliminary tests show no decrease in emission after a year's operation.

An interesting development resulting from the researches of Professor H. E. Edgerton and K. J. Germeshausen of the Massachusetts Institute of Technology is a new small stroboscope intended primarily for speed measurements. The instrument is entirely self-contained, weighs 12 lb., and requires 30 watts from the 110-volt, 60-cycle power. The rate of flashing is controlled by an illuminated dial with two scales—600 to 3600 and 2400-14,400 revolutions per minute. The speed-indicating dial controls the frequency of a relaxation oscillator and has a frequency variation that is nearly linear with respect to the position of the dial. Provision is made for adjustment of the oscillator in order to match the frequency of the oscillation with that of the numbers on the reading dial. A small reed (120-cycle) is located in the reflector so that the calibration may be checked and adjusted while the instrument is in use.

Electronic devices have also furnished a solution to the problem of controlling and recording water levels in model studies of tidal flows being made of the Cape Cod Canal. This study, made for the United States Army Corps of Engineers by the Department of Civil Engineering of the Massachusetts Institute of Technology will serve to determine the dredging profile for an enlarged channel taking into account the changed water levels resulting from altered flow between Buzzards Bay and Cape Cod Bay. In the model basins representing portions of these bays, water level is controlled by motor-operated weirs. Each motor is controlled by thyratron tubes which in turn are controlled by a vacuum tube by variation in the capacitance between a plate and the water surface. This work has been in charge of Professor Hazen of the Department of Electrical Engineering at M.I.T.

Closely associated with electronic research are the recent developments on direct current transmission utilizing electron tubes. This development has been discussed in another section of this issue. This work is being continued, and the equipment involved is being closely studied in regard to its operating performance. All metal hot cathode Thyratron and Phanotron tubes operated successfully in the 3000 kw. test set. In the investigations made during the year, it was found that two rectifier or inverter units will operate satisfactorily in series at 30,000 v. and 5 amp. and also that two units may be operated from a single monocyclic network.

Lightning research also is being continued along various lines, some of which have already been referred to in other sections of this issue. During the year a lightning observatory was constructed by one of the leading electrical manufacturing companies for obtaining lightning data with particular reference to multiple strokes. This installation includes a special camera with a rotating film arranged with 12 lenses so that all lightning discharges occurring anywhere within the entire 360 deg. is recorded. Although this structure was not completed until the lightning season was well advanced, some 52 strokes were recorded, 40 of which were single and 12 multiple.

There has been a great deal of activity in magnetic research. Theories of ferromagnetism are much better understood and as a consequence of this and the work done in alloys, many new and remarkable magnetic materials have been developed. One of these is Alnico, an alloy so much more powerful than those commonly

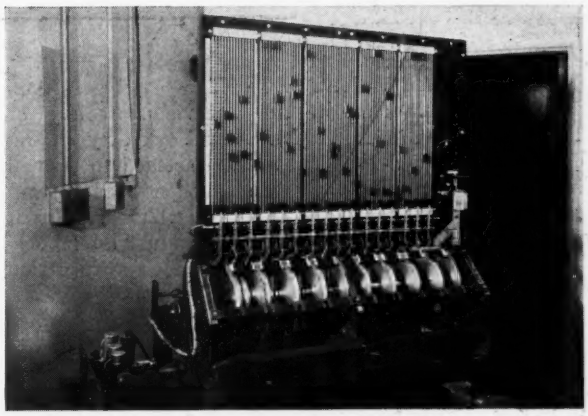


Fig. 2. Electrostatic audio-generator developed at the State University of Iowa

used before as to open entirely new fields of application for permanent magnets. Small motors and various control devices hitherto operated by electromagnets can now use permanent magnet fields. Alnico magnets will lift about 60 times their own weight.

Although designed specifically for psychological tests, a new electrostatic audio generator, developed by E. B. Kurtz and M. J. Larsen at the State University of Iowa, should prove useful in many other ways. It is a multi-harmonic audio frequency generator, the harmonics being generated singly by the rotation of a shielded segmented disk adjacent to a stationary wave pattern plate.[12]

There have been many important developments in the communication field during the year and research is being carried out on all fronts. Television continues to be a major element in this research and within a few months there will be several television stations on the air. During the year R.C.A. appropriated $1,000,000 for the development of television for the home. The two systems in this country which offer the greatest possibilities are those of R.C.A. and Farnsworth. These are both "electronic" systems and are already well developed. The electron multipliers used in these systems are of tremendous interest not only for their use in these television systems but for their possible application in other fields.

[12]An Electrostatic Audio Generator. Electrical Engineering, September, 1935, p. 950.

The Fifty-Sixth Annual Meeting *of the* A.S.M.E.

Scientific Research into details of operation and design were outstanding features of this mechanical engineering meeting

WITH A REGISTRATION of 2100 engineers during the meeting of the American Society of Mechanical Engineers, held in New York City on December 2 to 6, old time enthusiasm seemed to prevail in all of the meetings. It was quite noticeable that the papers presented were in large part the results of research carried on in college and industrial laboratories and investigations into the practical operation of equipment of recent developments installed in the field.

One outstanding event of the meeting was the annual dinner at which the President, Ralph E. Flanders, gave the Towne Lecture and President's Address, on the subject, Pioneers on a New Frontier. In this he pictured the passing of the frontier of land, mines, and forests, stating that the outstanding historical event of our generation is the disappearance of this frontier and the consequent disappearance of the old trusted and tried opportunities for youthful opportunity and the profitable investment of capital and with these gone there is beginning to go that favorable constructive type of national psychology which has energized our progress hitherto.

William L. Batt

Then he raised the question What shall we do in the face of an emergency so fundamental? His answer was that two courses are open to us. We can readjust our social, political and industrial institutions to a future of limited opportunities for men and for money with a national outlook keyed down to safety as our objective, instead of the old purposeful advance for the better future. The alternative is that we find an equivalent for the lost frontier—an equivalent that will as effectively open new opportunities for men and for capital and make it possible for us to retain our constructive national philosophy.

For the time being, he thinks, we seem to be making the first and poor choice. In some directions, deliberately and in others by direction, we are slowing down our production of goods and services. In place of the confident advance toward business risk and personal adventure, we are all playing safe—business men, worker and farmer. We are at this moment organizing a new world of restricted production, restricted human enjoyment and restricted opportunities for the coming generation. We have chosen to play the lesser part.

In his opinion, we need not do this and we must not do it. For the effective equivalent of the old physical frontier lies ready at our hands for our occupation, development and enjoyment. That frontier lies so close at hand that it escapes our notice. Its separate features are so familiar to us that we have missed its significance as a whole. For the new frontier is not a distant physical region, it is an ever present social possibility. This new social frontier is a greatly raised standard of living for the masses of our fellow citizens. In a society dedicated to this end the engineer will find profitable employment, satisfying recognition and useful essential service of the general good. With the scientist, the inventor and the broadly visioned business executive he will pioneer in the founding of a new order as far surpassing our present one as that does the barbarism of earlier ages.

New Officers Announced

What is known as Honors Night and John Fritz Medal Presentation was held on Tuesday evening at which A.S.M.E. awards were conferred upon recipients

and the Thurston Lecture delivered by Charles H. Purcell on the Construction Methods and Equipment on the San Francisco-Oakland Bay Bridge. It was at this meeting also that the results of the election were reported and the following new officers announced: President, William L. Batt; Vice-presidents, Alex D. Bailey, John A. Hunter, R. L. Sackett, William A. Shoudy; Managers, William L. Dudley, Walter C. Lindemann, and James W. Parker.

Cost of Power Distribution

Because of its controversial nature, the paper by Morris L. Cooke, director of the Rural Electrification Administration, on Power Distribution Costs brought more comment than others presented at the meeting. In summary, Mr. Cooke stated that because approximately half of the nearly $2,000,000,000 per year paid by consumers of electricity is to meet the cost of distribution, it is important that the utility industry develop adequate up-to-date cost finding methods comparable to those practiced by other great American industries.

Cost finding is intimately related to rate making and scientific cost finding methods will enable the industry to restrict unreasonable popular demands for reduced rates. The present trend toward a public policy of strategically located public power enterprises or "yardsticks" will necessitate the adoption of reliable methods of cost finding and detailed accounting records for comparative purposes.

Mr. Cooke pointed out that studies carried on by the Power Authority of the State of New York in 1934 indicate that reasonable cost of distributing electricity to urban homes with an average annual consumption of 600 kw-hr. per year does not exceed 2½ cents per kw-hr. and that the cost of distribution per kw-hr. decreases to approximately 1.7 cent for an average annual consumption of 1200 kw-hr., 1.1 cent for an average of consumption of 2400 kw-hr. and 0.7 cent for an average use of 4200 kw-hr. per year. It is imperative that the industry replace confusing data with orderly data, Mr. Cooke said, in conclusion, because the public is becoming impatient with generalities such as are exemplified by common assertions concerning the overall significance of taxes as an element of cost.

Discussion of this paper was not all one-sided. Prof. Wm. D. Ennis stated that we lack complete book records for construction costs. It is insufficient justification for this that the courts have stressed reproduction costs more than recorded cost in the determination of the rate base and have paid little attention to segregated construction cost. One of the major importances of costs arises from their influence on rates but rates to various customer classes are not and should not be solely determined by respective costs. There is, for example, the influence on future costs to be considered. If at any time of the day or year the load is less than the existing necessary capacity, then it pays to offer current at a bargain rate during such time—pays the special customers involved, the company and all other customers. Traditionally, bargain rates have been named to industrial consumers because they had to be. It may be that they should be extended to other classes of customers. That depends largely on the elasticity of demand which may result from rates below 4 cents to resident customers. The principle of increment costs is sound but who is to occupy the incremental position? There is the real issue and almost the only genuine issue in electric rate making.

King Hathaway stated that such contacts as he had had with utilities have not led him to believe that there is any tendency to lie down on the job, to countenance flagrant inefficiency and make up for high costs by padding so-called fair investment. It was his opinion that the failure of utility management to espouse a system of fact revealing cost accounting may be due more to the fear that facts so brought out might be unintelligently used by reactionary bodies and result in unreasonable if not unfair regulation. One prime essential to progress along the lines of Mr. Cooke's paper has long impressed Mr. Hathaway as being in too great a degree lacking—that is an understanding confidence in each other between the owners and managers of utilities on the one hand, and those representing the public.

"The report by the Power Authority," said N. E. Funk, "dealt with the property and operating expenses required for residential service without adequate consideration of the other component parts of the business. An abundant and reasonably priced supply of electricity for industrial and other purposes may be considered just as much a social necessity as a supply for domestic consumers. It is essential to consider the business as a whole in each community in order that rate schedules may not be discriminatory and provide service to certain classes of customers at less than cost."

With the point of view and the general argument, H. C. Persons was in agreement with Mr. Cooke, but with a number of specific propositions he was of the opinion that adjustments in management will have to be made. The problem, he thought, is not so much one of technical difficulty as of will to do, clear understanding of the order of accounting and cost finding in ques-

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"If, faced with the disappearance of the physical frontier, we cravenly resign ourselves to accepting that fact as final, and key our national policy and our national hopes down to that dismal decision, there will be little future for the engineer. There will be fewer of us, and our services will be of a subordinate order.

"If, on the contrary, we make the more courageous decision to replace the lost physical frontier with the new social frontier of the raised standard of living, then the engineer will come into his own.

"For the raised standard of living demands more goods and services, of better quality and at lower cost. This is the service which the engineer is qualified to render. To this was he born; for this was he educated; this is his life work. In a society dedicated to this end he will find profitable employment, satisfying recognition, and useful, essential service of the general good. With the scientist, the inventor and the broadly visioned business executive he will pioneer in the founding of a new order as far surpassing our present one as that does the barbarism of earlier ages."—Ralph E. Flanders.

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tion, suitable organization for its development and continuing high executive support.

R. T. Livingston stated his amazement that the paper was ever accepted for presentation at an A.S.M.E. meeting. "It is not," he stated, "mechanical engineering nor even engineering, and certainly conveys an erroneous impression. It is propaganda. In view of the fact that the fundamental postulate is in error, it is hardly necessary to point out that the paper itself does not warrant serious consideration were it not for the fact that the author occupies a position of trust and responsibility in the present administration. It is hardly possible in a single discussion to completely present the whole problem which has been brought up and at the same time point out the many misstatements in the paper." To summarize his lengthy discussion, it may be stated that he considers Mr. Cooke's premise that public utilities do not keep proper accounts nor adequate cost records as a fallacy, as there are few cases in industry where such complete and accurate records are kept in such meticulous detail as is done in the public utilities; that these cost determinations are available and are used. "Both of these facts" he stated, "are well known in the profession and cannot be altered by repetition or statements to the contrary."

"It is not the machine that causes human misery but our failure to absorb the machine, and the power that drives, into our social and economic processes. We are in an age of technology but we have failed to revise our cultural patterns to embrace technology. Insofar as labor-saving machines are installed when plant and society are unprepared to cope with the human problems they create, in that far these machines will surely continue to saddle us. The fault, however, lies largely in our technoculture; and the unemployment that follows is, as I see it, technocultural unemployment."—E. F. Baker.

"It is particularly difficult to those of us within the industry who share Mr. Cooke's ideas," said Hudson W. Reed, "to have someone in his position make statements which cannot be demonstrated on the basis of actual conditions. If men such as he will hold for us reasonable objectives, we can coöperate with him in attempting to reach them. If objectives are impossible of attainment, we can only feel that we are faced not with coöperation but with destructive conflict."

Presenting some findings from the survey made by the Power Authority of the State of New York, George H. Morse gave the following average values of the elements of cost of distribution per customer, weighted as to the number of customers: depreciation expense (3% of investment) $2.05; taxes $0.90; return on investment (7% of investment) $4.77; distribution and maintenance $2.13; utilization expense $0.81; commercial expense $2.30; new business expense $0.70; general expense $1.77; the annual average cost per customer and average cost per kw-hr. both weighted as to number of customers, were respectively $14.80 and 2.11 cents.

Research to Advance Power Generation

Those responsible for the selection of papers presented at the power sessions presented a program that was largely the results of research and mathematical calculations, considerably in advance of present day engineering but should point to practical solutions of problems now confronting the industry. Such a paper was that presented by Frederick G. Straub, who stated that a survey was made of power plants encountering turbine-blade deposits and it was found that this trouble results from contamination of the steam by the boiler water. A study in the laboratory showed that sodium hydroxide is the material which causes the sticking to the blades. It was also shown that when the sodium hydroxide is neutralized and changed to a salt such as sodium carbonate, it will not adhere. The presence of sufficient amounts of inert salts, such as sodium sulphate, with the sodium hydroxide also will stop the deposit from forming.

The action of sodium sulphate in preventing the blade deposits was studied in a large central power plant, and the deposit was materially reduced. A small testing unit for detecting the presence of adhering salts in the steam was developed and used in the power plant tests.

The difficulty caused by the deposition of solids carried in the steam appears to be the one causing the major difficulty. The efforts of this research have been expended entirely toward the study of this type of deposit and no study has been made of the other type.

The summary of conclusions reached after assembling the available data in regard to turbine-blade deposits is as follows:

(1) The deposits formed independent of steam pressure or temperature.

(2) The deposits were not proportional to the total concentration of solids in the boiler water.

(3) The total solids in the steam were very low in many plants where deposits occurred.

(4) The deposits all contained sodium, present as hydroxide, carbonate, or silicate.

(5) The deposits were practically all water-soluble.

If sodium chloride, sodium carbonate, or sodium sulphate were present in the boiler water the droplet of water entering the superheater with the steam would contain a dilute solution of the salt or salts. As the steam became superheated the water would vaporize and leave a dry salt or powder of the salt or salts with the superheated steam. Consequently, they would pass through the steam pipes and turbine as a fine powder or dust and cause no appreciable difficulty. This is based on the assumption that there is only a small percentage of moisture in the steam. However, if sodium hydroxide were present this would not happen. This results from the fact that the behavior of sodium-hydroxide solutions is entirely different from that of the other salts discussed.

A summary of conclusions drawn from the results of this work is as follows:

(1) The basic material causing turbine-blade fouling is sodium hydroxide.

(2) Inorganic salts, such as sulphate, chloride, and carbonates, if present in sufficient amounts, will prevent turbine-blade fouling.

C. E. Peck and M. D. Ross discussed the develop-

ment of an airfoil-type propeller blower, the design of which was influenced by space limitations in connection with the motor-driven blower equipment for a 165,000-kw. turbine-generator unit installed at the Richmond Station of the Philadelphia Electric Co. After the fan was designed, a model was built and tested before the full-size equipment was constructed. Performance data were given for both the model and the full-size blower.

The results of designing, building, and testing a fan of this type brought out the following possible advantages:

1. Within certain limits the performance and design proportions can be predetermined accurately.
2. From a mechanical standpoint, the propeller is particularly adaptable for high speeds.
3. The intake box has little effect on the fan performance.
4. For the pressures and volumes used in this application, the size of the unit is reasonably small.
5. The fan efficiency is high.

In the course of the revision of the A.S.M.E. test code for steam turbines, there has arisen among several members of the committee charged with that task an informal discussion of the method of observing data for the computation of turbine efficiencies. In order to put on record the opinions of engineers familiar with the problem, C. Harold Berry proposed that hereafter turbine test methods shall call for the measurement of the impact pressure and temperature of the entering steam and the impact pressure of the exhaust steam. It was contended that this is a correct method, and that the use of static values is incorrect. It was further contended that the impact values can be measured with somewhat higher precision and perhaps more easily. It was conceded that the numerical change in final results will be small, but this is no argument, since the change is in the direction of a closer approach to truth and fairness, and since it is common to make provision for determining other quantities that are no larger.

It was contended that the use of static-pressure observations in this connection is incorrect, and that the values that should be observed are the impact pressure and temperature of the entering steam and the impact pressure of the exhaust steam.

Thus the present proposal boils down to this: In order to measure the aggregate energy supplied to a turbine and rejected by a turbine, the initial pressure should be measured by a properly placed impact tube, the initial temperature should be measured by a thermometric element subjected to the full impact of the moving steam, and the exhaust pressure should be measured by properly located impact tubes.

Objections to this proposal brought out in the discussion were that the difference is not great and can be readily corrected; instruments for measuring impact lack necessary accuracy; measuring moist steam is extremely difficult; and the kinetic energy is too small in many cases to warrant consideration. Several, however, thought the proposal warranted consideration and a tryout in the field.

In the field of the designing engineer, Adolf Egli derived the general relation between weight and flow, speed and efficiency of a reaction-blading group as used in steam turbines under various steam conditions. With this relation, which is best plotted graphically, Mr. Egli presented a method for calculating the peculiar variation of the weight of flow in variable-speed turbines. The conclusion arrived at mathematically is that the weight of flow through a symmetric reaction-blading group is in general a function of the pressure ratio, velocity ratio, blading efficiency, and initial condition of the steam.

That water and steam have appreciable viscosity was demonstrated in research work carried on at Purdue University and reported to the Society by G. A. Hawkins, H. L. Solberg, and A. A. Potter. The authors presented in this paper data on the viscosity of water and superheated steam at temperatures and pressures used in modern power plant practice. Apparatus was constructed to measure the viscosity of water and superheated steam at pressures up to 3500 lb. per sq. in. abs. and at temperatures up to the critical in the case of water and between 800 deg. F. and 1000 deg. F. for superheated steam. The apparatus was described and the results obtained with it were reported in the paper.

Data on the viscosity of water and superheated steam are very meager or nonexistent at the temperatures and pressures which are used in modern power plant practice.

"Demands for higher efficiencies of equipment in certain engineering fields have necessitated the use of higher temperatures as, for instance, in boiler and turbine construction. Dimensional change of metals under stress at these elevated temperatures over long periods of time presents a problem that is becoming constantly of greater importance to the engineer and metallurgist," said L. L. Wyman in his paper on The Creep of Steels as Influenced by Microstructure.

"The metallurgist is confronted with the problem of obtaining materials suitable for such service. When it is considered that the designers of such equipment demand materials which can resist a stress of 30,000 lb. per sq. in. without showing a total dimensional change, or creep, of more than the order of 1 mil. per in., or 0.1 per cent, at the end of 100,000 hr., which is more than ten years, at 450 deg. C (842 deg. F.), the selection and testing of materials can only be made justifiably as a result of long-time creep tests covering thousands of hours under stress at elevated temperatures.

"Past experience has shown that resort must be made to alloy steels for such high-temperature service, and, as the future indicates still higher operating temperatures, it is evident that steels of high alloy content must be used." In order to show the significance of structural uniformity on the creep properties of some steels, the results of several experiments were described.

William Hovgaard explained his algebraic method of calculating the couples, forces, and stresses in a three-dimensional pipe line fixed at the ends, consisting of straight parts, at right angles to each other connected by quarter bends. The solution is complete in that it takes account of bending, torsion, compression, and shearing. It comprises a special discussion of the rotations and deflections of quarter bends when subjected to forces and couples acting normal to their plane, with particular application to the three-dimensional pipe line. He also gave an analysis of the

stresses at the terminal sections and in the bends, together with a discussion of the strength criteria and the permissible working stresses.

Coal and Combustion Equipment

Recognizing that underfeed stokers play an important part in the burning of coal in many sections of the country, a committee of fuel engineers representing Appalachian Coals Inc. presented a paper on the selection of coals for use in this type of equipment. Among other things, it calls attention to some of the factors which complicate the problem of coal selection. There is also pointed out the effective work now being done, both inside and outside the coal industry, to develop a clearer understanding of the factors involved in coal selection and application.

An analysis of data on 7284 industrial plants, accumulated in a market survey, reveals the prominent position of the underfeed stoker. This survey covered the principal market areas for southern high volatile coals and included approximately 15,000 coal-burning units in industrial plants located in Georgia, eastern Indiana, central and eastern Kentucky, the lower peninsula of Michigan, North Carolina, that part of Ohio west of the Sandusky-Galion line, South Carolina, and western Virginia. A summary of the coal-firing equipment in use in the plants covered by the survey was given.

The total coal involved annually is 19,634,266 t.; of that amount, 9,429,375 t. or 48.1 per cent is burned on underfeed stokers. Out of a total of 2,532,692 b.hp., underfeed stokers account for 1,139,292 b.hp. or 45 per cent. The number of underfeed units is 4423.

The average horsepower of the 14,532 boilers is 174.3, whereas boilers fired with underfeed stokers average 257.6 hp.

Of special interest is the large number of hand-fired boilers, numbering 8878 units, with an average of 106.8 hp. From a coal-consumption standpoint, these hand-fired boilers rank next to underfeed stokers with an annual consumption of 4,089,827 t., or 20.8 per cent of the total.

While the results of the survey are of extreme interest the real value of the paper to the plant engineer was the comprehensive presentation of the factors that enter into the problem of selecting coal for underfeed stokers. Space at this time does not permit printing an adequate abstract of the data presented but it will be used in an early issue.

Not many underfeed stokers are equipped with means for supplying the combustion air in metered quantities to individual zones of the fuel bed. This fact enhanced the interest in the symposium on this subject which was contributed to by H. E. Macomber and A. S. Griswold, both of the Detroit Edison Co., and J. N. Landis of the Brooklyn Edison Co. The general conclusion was that:

The use of either manual or automatic metered control for the distribution of air supplied to large underfeed stokers is justified in present-day operation, although the automatic metered control accomplishes more as it adjusts the air flow instantaneously and continuously, whereas the manual metered control depends upon the operator's observing the air-flow gages and making the necessary adjustments of metered-air control increases, by 23 per cent or more, the maximum attainable combustion rate of the stoker which can be carried successfully. Stoker maintenance cost is appreciably reduced through the reduction of burn-outs. The availability of the unit is correspondingly improved because of less frequent shut down for repair. Reducing the excess air improves efficiency, particularly at the lower fuel-burning rates. Smoke is almost entirely eliminated under all conditions of operation. Because of the increased fuel-burning rate made possible, a smaller stoker can be used, which in some cases leads to marked saving in the entire boiler-plant investment.

"But opportunities for the use of skill have decreased alarmingly, during the last years, with disastrous results. Industry is already in need of more skilled men than are available. The unemployed who were highly skilled have lost some of their expertness, through lack of opportunities to keep up with new information, to practise, and to adapt to new demands. The injury to their morale, through unemployment, makes it difficult for them even to try to come back."—Lillian M. Gilbreth.

While fuel burning equipment has, on the whole, kept pace with the remarkable developments in steam boiler design and practice during recent years, there have nevertheless been limitations when burning certain midwestern coals of low ash fusing temperatures on underfeed stokers. Now a water-cooled stoker has been developed which has been tried out successfully at the Cedar Rapids power plant of the Iowa Electric Light & Power Co. With this stoker it is possible to burn a cheap northern Illinois coal at high rates of combustion with pre-heated air at 425 deg. without burning of the stoker parts or slagging over the fuel bed.

The design and development of this water-cooled underfeed stoker was described by J. S. Bennett and C. J. Herbeck. A header at the bottom of the stoker ashpit is supplied by a downcomer from the boiler drum. The water from this header rises through tubes placed along the face of the stoker ashpit. Some of the tubes continue along the line of the tuyeres into a header in the front wall, and others are carried under the bottom fuel-distributing pushers into a header placed in the windbox. There is no moving over-feed section, characteristic of all previous high-duty underfeed stokers.

Fuel-burning rates up to 54 lb. per sq. ft. of air-admitting surface per hour have been maintained, with negligible combustible in the refuse and with a clear furnace and stack, an important feature, considering the fact the release rates in the furnace ran as high as 58,000 B.t.u. per cu. ft. per hr. with coal containing 37 per cent of volatile matter. The maximum coal-burning capacity of the unit has not been determined because of the limitations imposed by the draft and the boiler.

Stoker water cooling should permit the use of higher air temperatures than have been employed previously. Experience indicates that the resulting loose

and homogeneous condition of the fuel bed allows a more effective use of the entire grate surface and should permit somewhat higher fuel-burning rates, and may be expected to be reflected in reduced slagging of the boiler tubes and generally improved performance. It is believed that this construction, while of great value in burning Middle West fuels, may be expected to be more important along the Eastern seaboard, where coals containing a small percentage of ash with a relatively high fusing temperature can be burned with extremely high pre-heat.

"The morale of destitute men who had been given 'work relief' or 'made work' was found to be definitely better than the morale of men who, although similarly destitute, had not received such help. The morale of employed men who anticipated losing their jobs almost any time was as low as that of unemployed men who were in no particular need."—Morris S. Viteles.

In the field of pulverized coal burning, R. Shellenberger presented a paper on Furnace Bottoms for Tapping Ash in the Molten State. "The combustion of pulverized coal in a slag-tap furnace," he stated, "occurs in two phases. The first takes place in the lower, high temperature, turbulent portion of the furnace. The second phase requires final completion of combustion and cooling the ash not collected in the furnace bottom to a state in which it will not slag boiler heating surface.

"Coals having a wide range of ash fusion-temperatures are suitable for use in slag-tap furnaces. Ash from coals having high sulphur and pyrites content are easily handled in properly designed bottoms. Adequate support and buckstay steel, however, is necessary.

"Wide flexibility and ease of tapping are possible with units of modern design. Tapping may be intermittent or continuous. Full utilization of highly preheated air may be obtained in the slag-tap furnace.

"Vertical turbulent burners lend themselves well to utilizing the full furnace volume and to focusing heat on the slag furnace for facilitating tapping under the widest range of ash fusion-temperatures and of boiler ratings."

Designers of boiler furnaces have through the years of development depended upon results in the field for their guidance in making changes in arrangements of heat absorbing surfaces. By this method of trial and error the development has been slow and expensive. Of recent years methods of computing heat absorption from furnaces have been devised and are proving helpful, printed information on the subject is not as plentiful nor as accurate as is desirable, and it was with the object of bringing together all possible data which would be of aid in designing boiler furnaces that two entire sessions of the meeting were devoted to radiant heat discussions.

W. J. Wohlenberg and H. F. Mulliken reviewed the recognized methods of computing heat absorption in boiler furnaces that are in use today, giving results obtained by each of a number of methods. These were compared with the results reported by the A.S.M.E. Committee on Absorption of Radiant Heat in Boiler Furnaces. Particular emphasis was placed on the Broido, Orrok, and Wohlenberg methods. It was shown that the influence of various conditions as found by experiment are in substantial agreement with results expected from a theoretical consideration of the problem and those arrived at by certain well-known methods now in use.

Another paper reported the results of an experimental investigation of heat absorption in boiler furnaces conducted by the A.S.M.E. Committee and presented by W. J. Wohlenberg, H. F. Mulliken, W. H. Armacost, and C. W. Gordon. The paper included test data obtained on ten boilers in different power plants in the United States. The investigation involved stoker-fired, pulverized-fuel, and oil- and gas-fired units with various combinations of refractory and water-cooled furnaces. The data include furnace-exit gas temperatures as measured by means of the high-velocity thermocouple. These temperatures were used to determine the fraction of heat input to the furnace that was absorbed in its walls.

Evaluation of effective radiant heating surface and application of the Stefan-Boltzman Law to heat absorption in boiler furnaces was dealt with by H. F. Mulliken. He developed a method for converting well-known types of furnace heat-absorbing surfaces into an equivalent effective radiant heating surface. It concerns the evaluation of this effective radiant surface as controlled by (1) various spacings of waterwall tubes, (2) various kinds of blocks on the waterwall tubes, (3) various amounts of slag on the waterwall tubes or blocks, and (4) the emissivity of the waterwall surface exposed to the flame. He also considered the fraction of heat supplied to the furnace that is given up by the gases in the furnace which is solved most simply and practically by the use of the Stefan-Boltzman radiation law.

Another factor involved in the design of boiler furnaces is the radiation from nonluminous flames which was considered by H. C. Hottel and V. C. Smith, who reported experimental results on the total radiation due to carbon dioxide, water vapor, and mixtures of the two that were obtained in a furnace, the maximum operating temperature of which was 1850 deg. F. The final plots were obtained by extrapolating to 3600 deg. F. the experimental data covering the range from room temperature to the furnace maximum.

A method was described for determining these properties directly in the upper temperature range. It consists of measuring the emission of radiation, and the corresponding temperature, from overventilated flames of carbon monoxide, hydrogen, and mixtures of these in a Meker burner of varying length. The products in the flame were calculated from the mixture fed to the burner.

Boiler Feedwater

As industry progresses, greater attention must be given to the finer details that press themselves into the picture as a factor requiring solution. Boiler feedwater treatment is one of those serious problems that seems to become more complicated with each step of advance practice in the boiler room and now one of the pressing problems is the purity of the steam. This phase of power plant practice was treated in a session

under the auspices of the joint Research Committee on Boiler Feedwater Studies at which some distinct aids to operators were presented as well as results of research in the chemical problems involved that point toward solutions of some of the most troublesome problems of today.

As the outcome of a desire to determine the accuracy of methods, using density measurements for the estimation of dissolved solids in boiler water and the regulation of boiler blow down, the chairman of Subcommittee No. 8 on Water Analysis of the Joint Research Committee on Boiler Feedwater Studies requested J. K. Rummel and J. A. Holmes to do the work incidental to making a comparison of and prepare a report covering the use of instruments commonly used for this purpose.

It is a well-known fact that boiler waters will vary in composition over a considerable range and that the individual dissolved solids in such waters are different in density. Thus, in the absence of any data to the contrary, one might assume that regardless of the accuracy of the density determination, it would not be feasible to construct a standard curve relating density and the concentration of dissolved solids, which would be of practical value. However, after a study of the available data, it is concluded that standard curves of this kind can be used successfully in the practical control of boiler water dissolved solids.

W. C. Schroeder and Everett P. Partridge reported the results of their investigations on the effect of solutions on the endurance of low carbon steel under repeated torsion at 482 deg. F. The stresses to which the steel in a boiler is subjected may be divided into two general classes: static stresses and repeated stresses. Both of these classes may play an important part in the type of failure regardes as, "embrittlement failure." The origin of the static stresses is inherent in the design of the boiler to withstand the steam pressure or structural load; the repeated stresses, however, are in the main incidental to the operation of the boiler. A wide difference can exist in the rate of repetition of any given stress. Heating up and cooling down the boiler may cause a stress which is only repeated at intervals of several hundred hours; temperature fluctuations and corresponding pressure variations may cause stresses which are repeated at intervals of a few minutes; while rapid vibrations, occurring many times a minute, arise from surges of water, from the rapid circulation of the water through the tubes and drums, or from the operation of related equipment.

Some interesting results from a series of tests conducted at 482 deg. F. on steel subjected to repeated stress in torsion while in contact with various solutions were described in the report. Although this work is only in its early stages, three important conclusions seem justified:

1. Contact with pure water or with solutions of such salts as sodium chloride, sodium carbonate and sodium sulphate, as well as sodium hydroxide, very markedly lowered the endurance of the specimen under repeated torsion as compared with its endurance under the same conditions in contact with air.

2. The reduction in the endurance of the specimens caused by contact with water or aqueous solutions in the absence of oxygen was apparently not due to localized corrosion or pitting of the steel surface.

3. The effect of sodium hydroxide in reducing the endurance of the steel can largely be prevented with sodium chromate or sodium nitrate.

New laboratory data relative to embrittlement in steam boilers were reported by Frederick G. Straub and T. A. Bradbury as the results of laboratory tests which they conducted and which show that purified sodium hydroxide will not produce cracking of steel test specimens in short-time tests, whereas technical sodium hydroxide made by the lime soda process will. When the impurities present in the technical sodium hydroxide are added to the purified caustic and then used in tests, the specimens crack. It appears that when silica is present in sufficient amounts, along with the pure caustic, cracking will take place. However, when smaller amounts of silica and small amounts of calcium, magnesium and aluminum are added to the pure caustic, cracking will also take place. These results indicate that it is apparently necessary to have one or more catalysts present in the sodium hydroxide solution in order to cause cracking within a reasonable period of time.

Cavitation Studies Reported

Cavitation tests made with model turbines at the Holtwood hydraulic laboratory of the Pennsylvania Water & Power Co. were reported by L. M. Davis, who pointed out the benefits which have been realized therefrom. In addition to presenting the results of these tests the author compared them with results obtained by other investigators in this field. He also presented his views regarding the further application of the equipment in the Holtwood laboratory for the purpose of investigating various elements in the design of turbines which may have some bearing on their cavitation characteristics.

Progress on cavitation research at Massachusetts Institute of Technology was reported by J. C. Hunsaker, who discussed information obtained regarding the relation between frequency of vapor collapse and the controlling variables. The current work tends to confirm that previously reported. A new method for the study of resistance to cavitation attack was described. An apparatus for oscillating a nickel tube at high frequency by magnetostriction effect was used to oscillate 5/8-in. disks of lead and cement with a frequency of about 8500 cycles per sec. through an amplitude of about 0.01 mm.

Tests are being made with a number of common liquids of widely different physical properties. Tests of lead disks in water or in a calcium-chloride solution show vastly more damage than when tested in alcohol or in carbon tetrachloride. It is found that either with lead or with cement, appreciable damage is done in one minute and a test can be completed in less than 10 minutes.

Lewis F. Moody and Alfred E. Sorenson reported the progress in cavitation research at Princeton university. The authors described test apparatus and an experimental method used to determine the critical point of cavitation, or cavitation limit, of liquids flowing in a closed system as caused by the formation of vapor-filled cavities in the system. The experiments described were directed to determine the cavitation limit, at which cavitation begins, and not to ascertain the consequences of maintained cavitation. The authors show

that the experiments give results entirely consistent with the cavitation principle as now generally applied.

Oil and Gas Power

For the most part the session on oil and gas power was devoted to the consideration of problems of lubrication and ignition. Station operating costs, however, has always been a live topic of discussion and a report was made on this occasion.

In discussing some of the developments made in establishing the significance of vaporization and decomposition of Diesel fuels during combustion in an engine G. D. Boerlage and J. J. Broeze made brief mention of those problems that can be solved by the engine designer. The combustion problem was divided into phases each assigned to its particular time; introduction of the fuel, atomization, vaporization, formation of mixture, decomposition, and combustion.

In reporting his survey on oil-engine-electric generating station operating costs, George C. Eaton stated that he dealt only with the operating economics of oil-engine-electric generating stations, no attempt being made to include fixed costs on invested plant. Analyses of previously published data to show the fuel consumption, fuel costs, and operating costs except fuel, as well as total operating costs, all referred to a "common denominator"—capacity factor, were explained and were illustrated by curves. Curves of unit costs in mils per net kilowatthour generated were also given. The data used cover 323 station years of operation, the stations varying in size from 1000 to 15,640 installed brake horsepower.

The report on oil-engine power cost for 1934 presented information on the production cost of oil-engine power plants. Production cost in the meaning of this report was defined as consisting of the following items: Fuel cost; cost of attendance and superintendence; cost of supplies and miscellaneous; cost of engine and plant repairs.

The report includes information from 160 oil-engine generating plants, containing 416 engines, totaling 222,620.5 rated b.hp. The total net output for the 160 plants amounted to 287,044,609 kw-hr.

Metals for High Pressure and Temperature

The instability of metals at high temperature was discussed by specialists who are rushing research work because of the demand of industry for higher temperatures and metals to withstand high pressures at higher temperature. This problem is of great importance to power industry, oil refining and chemical industries. Further cheapening of processes are held up by the difficulty of metal to withstand the desired temperatures and pressures.

R. W. Bailey, a leading authority in this difficult field of research in England, connected with the Metropolitan Vickers Electrical Company, Ltd., in Manchester, England, discussed the failure of steels under creep steam turbine parts. Fracture in general results from intercrystalline cracking. Particularly the steels showing a high resistance against the slow creep and flow are apt to break this way.

R. G. Strum, C. Dumont and F. M. Howell presented evidence to show what appears to be a basic law of creep of metals. Various interesting and important conclusions were drawn from their work with regard to the susceptibility of a metal to creep, the effect of composition, strain hardening, heat treatment for pure aluminum, aluminum alloys, copper, steel and monel metal.

A. Radai and E. A. Davis correlated the results of tests made under considerably varying conditions. A metallic bar may be stretched at a constant rate of deformation, or under a constant stress or in a relaxation test. It was shown that these and still more other kinds of tests can all be predicted from three fundamental creep equations based on a minimum of assumptions.

C. C. Anderson described an ingenious method to determine these detrimental stresses in cold-drawn bars or tubes. These latter were gradually dissolved in acidic solutions and the strains measured while certain portions of the specimen went into solution. The paper showed how stresses can be reduced by different ways of annealing.

Recent Development in Condenser Tubes

As a result of the investigation of test methods now in use for determining the comparative resistance of condenser-tube alloys, the Subcommittee on Standards of the A.S.M.E. Special Research Committee on Condenser Tubes reported that testing by impingement attack and by the use of experimental condensers operating under controlled conditions produce results of considerable value in predicting the relative service characteristics of the alloys. It was pointed out, however, that the ultimate comparison must be determined by actual service, even though actual service does not permit suitable control for standardization of conditions.

The Naval Engineering Experiment Station at Annapolis, Md., has been conducting a series of experimental condenser tests for more than 6 yr. in which a number of condenser-tube alloys are being compared. The test equipment consists of eight small single-pass condensers grouped radially about vertical distribution headers for steam, cooling water, and condensate.

Various condenser-tube materials have been tested or are now being tested in these condensers. One Admiralty-metal tube failed after 1250 hr. of actual operation. However, the remaining 15 Admiralty-metal tubes are still in service after a total of 11,300 hr. Monel metal has given satisfactory service up to the present time, no failures having occurred since the start of the test, a total of 11,300 hr.

One type of 18-8 stainless-steel tube failed after 625 hr. of operation, as did two different grades of tubes, containing approximately 17 per cent chromium without the addition of nickel, after 950 and 1060 hr. of service. Other alloys of the 18-8 type, however, are still in operation after 4000 to 5000 hr.

Two grades of aluminum-bearing copper-zinc tubes failed after a comparatively short time although two other grades have been in operation for approximately 2525 and 3850 hr. and still appear to be in good condition. The copper-nickel alloy tubes of various compositions appear to be in good condition after approximately 9300 to 10,300 hr. of service. There are a number of tubes of other compositions in the condensers at the present time, but because of the short interval since their installation, no decided deterioration of failures have occurred up to the time this report was compiled.

New Equipment

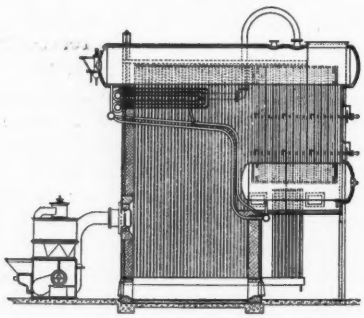
New Gasket Design

EMBODYING ALL PRINCIPLES of Flexitallic construction, plus a centering guide which insures correct seating and simplifies installation, the Flexitallic Gasket Co. of Camden, N. J., announce a new Style D gasket for raised face, plain, Van Stone or Cranelap pipe flanges for all pressures up to 1500 lb. The centering guide so designed that the gasket proper is entirely within the bearing faces are made in conformance with A.S.M.E. flange standards. For pressures of up to 600 lb. inclusive, the metal employed is cold rolled steel; above

600 lb., stainless steel or monel, although for temperatures above 500 deg. F. stainless steel is recommended for all pressures. For special fluid conditions copper or bronze may be used and for some services it is advisable to have the gaskets proper made of one metal, the guide of another. For all sizes and all conditions the Style D Gasket is made ⅛ in. thick.

Keeler Water-Tube Boiler

EMBODYING A NUMBER of important features, the new type CP water tube boiler is being offered by the E. Keeler Co., Williamsport, Pa. The unit is completely steel encased and insulated, the only brick work required being a front wall and bridge wall. Sides of furnace are water cooled by tubes extending out and down from the main drum and terminating in headers. This water cooled construction eliminates troubles from clinkers, reduces furnace cost to a minimum and provides higher capacity for given space. The unit can be operated at high overload without disturbing the water level. A soot blower is incorporated in the boiler which has been designed to facilitate cleaning both the inter-

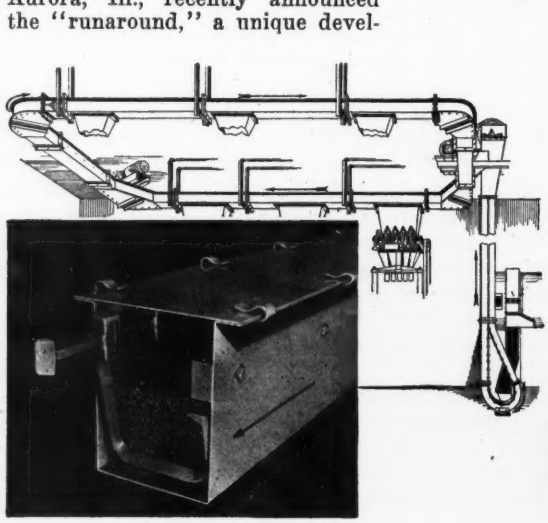


ior and exterior. This boiler is built in a complete range of sizes up to 250 hp. and for pressures up to 450 lb. per sq. in. and the unit may be shipped completely assembled. It is available for all types of firing and may be used either with or without superheaters.

Runaround Conveyor

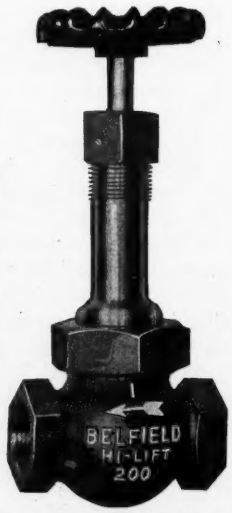
STEPHENS-ADAMSON MFG. CO., Aurora, Ill., recently announced the "runaround," a unique development of the Redler conveyor, said to be the only type of conveyor that will convey a steady column of bulk material (1) in several directions, (2) around horizontal curves, (3) discharge at any point, (4) return any surplus back to the feed point for recirculation and (5) handle so gently that there is no breakage or dangerous dust created.

This "runaround" Redler conveyor feeds itself a uniform load from bin or spout and opens up unlimited possibilities in conveyor arrangements for distributing material to scattered bins, processing machines, etc. It handles with perfect cleanliness and eliminates the necessity for accurate feed control as any discharged material is carried back to the feed point. Here the conveyor feeds itself only enough new material to complete a normal load regardless of the volume being recirculated.



New Control Valves

H. BELFIELD CO., Philadelphia, Pa., have developed two new valves for industrial service. The first is the Century Union Bonnet valve, built in sizes from ¼ to 2 in. for 200 and 300 lb. W.S.P. This valve has a non-rising stem, streamline flow and was developed particularly for chemical and oil industries as a regulating or control valve to correct the difficulties encountered in these industries with

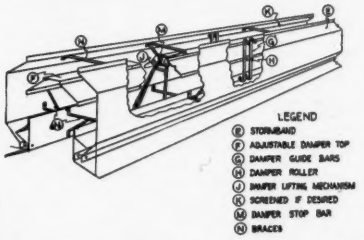


the rising stem valve which with certain fluids causes gumming or corrosion on the stem where it comes in contact with the atmosphere. The valve has a streamline body or web to reduce pressure drop. As the wear of the thread occurs only between the stem and disc holder, the valve is inexpensive to repair.

The second valve is the Hi-Lift V-port hand operated regulating or control valve built with a deep web permitting full areaway and a long V-port disc or plug. This valve is also built in complete range from ¼ to 2 in. in bronze up to 150 lb. and in steel up to 300 lb. The micro-thread is kept away from contact with fluid passing through the valve and the design permits close regulation or adjustment by hand.

New Ventilator

ANSWERING THE NEED for a gravity ventilator which would harmonize architecturally with building design and avoid the broken, rough line of unit ventilators, The Burt Mfg. Co., Akron, O., devoloped its new Monovent Continuous Ridge Ventilator which is adaptable to a roof of any pitch, requires no framing or special treatment and may be applied to roof ridges, slopes, decks or even built-up curbs.



It is constructed in 10 ft. sections which fit together uniformly with no tailoring in the field. The new ventilator is built in from 3 to 24 in. sizes, the capacities of each 10 ft. section ranging from the equivalent of one 20 in. unit ventilator for the 3 in. size to one 72 in. unit ventilator for the 24 in. size.

Burgess Acoustic Communication Booth

A NEW TYPE of telephone booth, built on the principle of absorbing extraneous sounds rather than blocking them, has been designed by the Acoustic Division of the Burgess Battery Company, Madison, Wisconsin. While the use of Burgess Acoustic Treatment in telephone booths is new, the principle of absorbing sound in this manner has long been applied by Burgess engineers in air ducts, airplane cabins, motor truck cabs, auditorium walls and ceilings, automotive mufflers, and in other places requiring acoustic treatment.

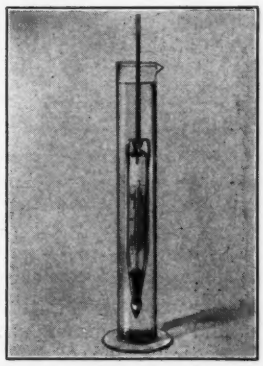
This new type of booth differs from wooden booths in that its interior is faced with Burgess Acoustic Treatment, a perforated metal sheet backed with balsam wool.

One of the new features is the absence of the door, which is made possible by the fact that the Burgess Acoustic Lining deadens extraneous noise more effectively than a closed door, and the speaker's voice is not transmitted beyond the booth. Extraneous noises, such as originate in steel mills, forging plants, power plants, punch press rooms, and other noisy factories, are instantly absorbed, producing within the booth a space of comparative silence. Conversations are easily maintained in places where speech would otherwise be impossible. For this reason Burgess Communication Booths may also be used to facilitate conversation between two workers in a noisy industrial plant. The booth is also open around the base, permitting adequate ventilation and easy cleaning.

THE B. F. GOODRICH CO., Akron, Ohio, announces it now offers a complete line of V-belts for both multiple and single drives. The Multi-V-belts are available in two styles, single strand construction for small pulley, short center, high speed drives and for larger drives, laminated construction.

Permutit Pacometer

FOR THE MEASUREMENT and control of boiler salines an hydrometer of rugged construction and high precision has just been announced by the Permutit Co., 330 West 42nd St., New York, N. Y., which has been given the trade name Pacometer (Permutit Automatic Compensating Hydrometer). This new instrument is calibrated for quick reading at either high or low temperature ranges and has a self contained thermometric correction scale in the bulb, which scale shows directly the density correction in the same concentration units as the stem itself. The radical change in construction is the design of the



stem which is made of a tough, durable, noncorrodible, highly polished metal. This stem is a strip about ¼ in. wide having the scale readings etched into its surface.

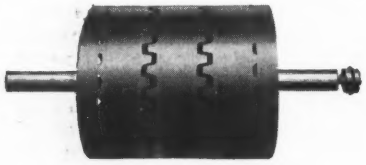
This thin, unbreakable stem enables a minute change in density of the liquid being tested to cause a relatively long rise or fall of the stem, which is synonomous with high sensitivity. Thus an accuracy of 10 gr. per gal., corresponding to a specific gravity of 0.0001, is guaranteed.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces a new 200-amp., engine-driven Shield-Arc welder to supply current for welding with electrodes up to ¼ in. diameter. It has a laminated magnetic circuit with interpoles, dual control of current at variable voltage by adjustment of series and shunt fields, separate exciter mounted on the generator end of the unit with field rheostat and current switch on the steel control panel. Drive is by a Waukesha 4-cylinder engine of 23 hp. at 1400 r.p.m. controlled by gear-driven governor, with high-voltage magneto for ignition, vertical type carburetor, and large gasoline tank above the generator.

High Intensity Magnetic Pulley

By Changing many features in the designs of its magnetic pulley, Dings Magnetic Separator Co., Milwaukee, Wis., has been able to increase the magnetic attraction and range of this device approximately 25 per cent.

Dissipation of heat and a properly designed magnetic circuit are essential to obtaining the greatest degree of magnetic intensity. The new magnetic pulley has transverse and longitudinal radiating ducts. Each coil is wound upon its own bobbin, which forms the core and the two poles. Separate bobbins are mounted upon the pulley shaft, each bobbin being securely keyseated to the shaft. The outer and inner faces of the bobbin are corrugated. This structure presents a



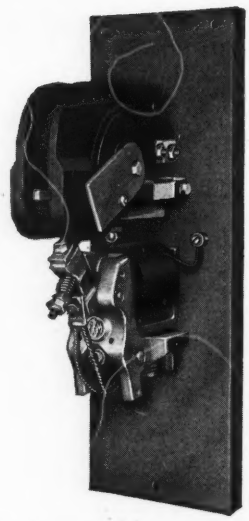
maximum radiating surface. Air passing through the radial and longitudinal openings insures a maximum dissipation of heat.

The coil covers are of heavy bronze thus preventing short circuiting of the lines of force between the two poles. The shaft is turned and polished. Each pulley is supplied with set collars, bronze collector rings with double contact brushes for each collector ring, dust proof collector ring housing and approved steel switch cabinet in which is mounted a pilot lamp with bullseye indicator to show when current is flowing, fuse, switch and special kick absorbing resistance to absorb the counter emf.

Line-Arc Magnetic Contactors

For use on mill, crane machinery controllers, and other direct current applications, The Electric Controller & Mfg. Co., Cleveland, O., announce a complete line of new magnetic contactors up to and including 800 ampere capacity, in which the arc, formed as the circuit is opened, is ruptured harmlessly in a narrow path or line centered between, but not touching, the arc shields.

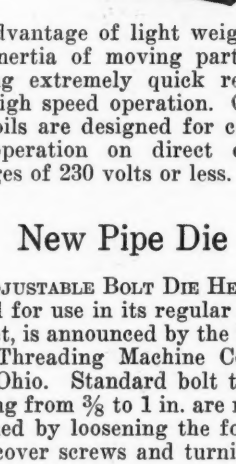
These contactors are made of a strong, aluminum alloy with magnetic parts of rolled steel which has



the advantage of light weight and low inertia of moving parts, permitting extremely quick response and high speed operation. Operating coils are designed for continuous operation on direct current voltages of 230 volts or less.

New Pipe Die

Adjustable Bolt Die Head, designed for use in its regular No. 00 ratchet, is announced by the Toledo Pipe Threading Machine Co., Toledo, Ohio. Standard bolt threads ranging from ⅜ to 1 in. are readily obtained by loosening the four die head cover screws and turning the

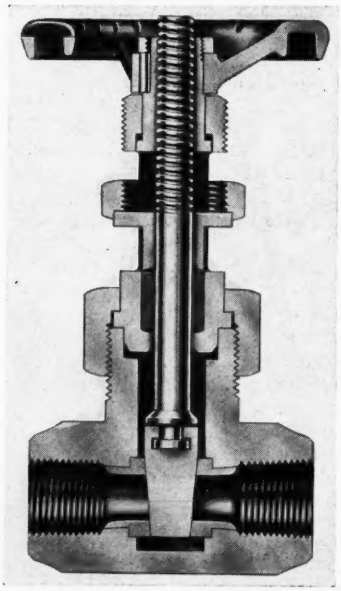


knurled ring until the dies are set at the desired size. Die segments are easily removed and reground when they become dull or may be replaced at small expense. Each die head is cadmium plated.

For use in heating submarines built by the Electric Boat Co. thirty-three 4-kw. Electromode unit heaters have been ordered from the Electric Air Heater Co., division of American Foundry Equipment Co. Most submarines built during the past few years have this marine type heater, other types, portable, industrial and built in units being used for heating buildings, isolated rooms and offices:

High Pressure Gate Valve

Machined from solid bar steel and carrying a 5 yr. guarantee, a new valve known as List 960 is being introduced by the Chapman Valve Mfg. Co., Indian Orchard, Mass. It is made in standard sizes from ¼ to 2 in., designed for services up to 600 lb. pressure at 800



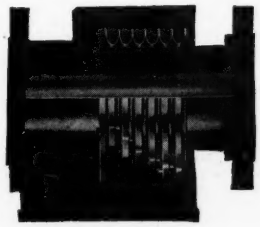
deg. F., or for cold working pressure, sizes from ¼ to 1 in. for a maximum of 2500 lb., and larger sizes, 1500 lb. Unlike the globe valve it is intended to replace, this valve has no pockets, raised seats or constrictions and in the open position forms a virtually unbroken continuation of pipe line and may be repacked under pressure. For extremely corrosive conditions, the valve is manufactured in stainless, monel or other special alloys.

Packless Expansion Joint

The American District Steam Co., North Tonawanda, N. Y., has patented and is placing on the market a new packless expansion joint, known as the U-Ring Type, for controlling pipe expansion in steam and hot water lines, or pipe lines conveying gases or fluids subject to temperature variations.

The expansion element, based on a new principle, is a series of die-formed U-Rings of stainless alloy steel welded together without transverse seams by a process which retains the basic strength of the metal. It is made with a wrought steel body which fully encloses the expansion element and

protects it from damage or dirt. The joint is available for pressures to 400 lb. and temperatures to 800 deg. F. with flanged ends or beveled ends for welding directly into the pipe line; with or without an-



chor base. Any reasonable amount of traverse can be provided, with a normal range of 1 in. to 8 in. The full amount of traverse is available as the element is under least flexing strain when the sleeve reaches its rated traverse. The new joint does not require service or maintenance and is especially desirable for underground pipe lines, power house piping or inaccessible locations where space is limited.

Large Welded Tanks

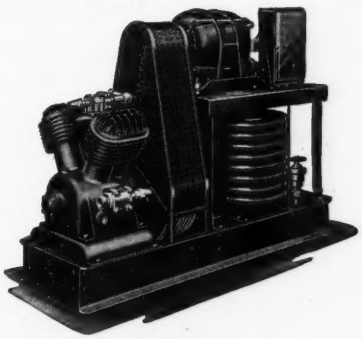
THREE 200,000-gal. tanks, each 60 by 38 by 12 ft. with two compartments, of ⅜-in. steel plate, horizontal braces 1¼ by 1¼ by ⅝ in. angles, vertical braces 1¼ by 1¼ by ¼-in. angles, all spaced 2 ft. centers and corner angles 3 by 3 by ⅜ in. were recently completed for Colonial Beacon Oil Co., a subsidiary of Standard Oil Co. (N. J.) by J. K. Welding Co. at Brooklyn, N. Y., a full month ahead of schedule. The tanks were of welded construction, trusses being lined and spaced in a jig, then placed on a ⅜-in. steel plate floor, resting on concrete and tied together by horizontal angles extending completely across the framing, all intersections being welded. Then side and end plates were attached and roof plates welded on. Fast welding was accomplished by the shielded arc equipment from Lincoln Electric Co. of Cleveland, seven weeks being taken from receipt of the first shipment of plate to completion of the last tank.

NEW WELDING ELECTRODES for stainless steel, belonging to the 25-12 variety, are announced by Lincoln Electric Co., Cleveland, Ohio. Because of its higher chrome content the new electrode, known as Stainweld B, is particularly advantageous for welding stainless clad steels, and is available in 5/32 and 3/16 in. sizes and 11 in. lengths.

Frick Freon Units

TWO NEW FREON UNITS, designed especially for the needs of air conditioning and water cooling work, are now being placed on the market by Frick Company, of Waynesboro, Pa. As shown in the illustration, the unit comprises an enclosed-type compressor, driven through V-belts by a motor mounted above the flywheel; underneath the motor case is the condenser coil.

The 15-t. machine has three vertical cylinders and is driven by a 15-hp. motor. The 20-t. unit has four cylinders, arranged in a V pattern and is driven by a 20-hp. motor. The capacities given are based on a suction temperature of 40 deg.,



which is becoming customary in air conditioning work. Both machines have cylinders of 4¼ in. bore by 4¼ in. stroke.

The condenser is a new type that gives extra cooling surface by nesting a number of small water tubes inside the large outer tube. The charge of Freon is carried in a receiver within the base, which is made of deep steel channels. The unit is complete with the necessary controls for full automatic operation, though it can be manually handled if desired.

It will be noted that for the horsepowers given, these units have an unusually high refrigerating capacity, which is made possible by improved compressor design, extra large condenser, and other refinements.

MONOBLOC centrifugal pumps designed especially for hotwell service and handling liquids near their vapor pressure are announced by the Worthington Pump & Machinery Corp., Harrison, N. J. Known as Type DH Unit, they cover a range of capacity from 10 g.p.m. against heads of from 50 to 100 ft. with 12 in. submergence to 175 g.p.m. at heads of 50 to 70 ft. with 60 in. submergence. The overall floor space occupied by the largest unit is but 24 by 16 in.

Midwest Engineering and Power Exposition To Be Held in Chicago

THE SEVENTH MIDWEST Engineering and Power Exposition and the Sixth Midwest Power Engineering Conference are to be held in Chicago during the week of April 20-24, 1936. This promises to be the big power event of the year in the middle west and great interest in it is anticipated.

The Exposition is to be held at the new International Amphitheater where excellent facilities for such an exposition are available. The great new exhibition hall is replete with the most convenient and smartest appointments for the most effective visualization of displays, as well as the personal convenience of those attending.

The Power Engineering Conference which is to be held in conjunction with this exhibition is being sponsored by the local sections and regional divisions of the following societies: American Institute of Electrical Engineers; American Society of Civil Engineers; American Society of Mechanical Engineers; Edison Electrical Institute; Western Society of Engineers; National Safety Council; American Society of Refrigerating Engineers.

Official hotel meeting headquarters will be at the Palmer House, Chicago, where the entire fourth floor has been reserved for meetings, lunches and receptions. Afternoon sessions will be held at the International Amphitheater where the Midwest Power Show will be held. Meetings are open to all persons interested, regardless of membership in the sponsor societies, but participating members must conform to registration rules.

Several committees have already started work for the four-day meeting so that the latest ideas in Power work will be presented. Several sessions are already planned covering specialized activities such as prime movers, refrigerating, electrical transmission and application, ventilating and coal utilization.

The work of carrying on the program for the meeting scheduled for April 20-24 inclusive at Chicago has been placed in the hands of the following: President, F. D. Chase, Chicago; J. R. VanPelt, Chairman, O. A. Anderson, Frank Innes, J. E. Kearns, G. E. Pfisterer and K. A. Auty, Chicago. Headquarters at 308 W. Washington St., Chicago, are busy on the elaborate program being prepared.

Stoker Manufacturers Hold Annual Meeting

AT THE 18TH ANNUAL MEETING of the Stoker Manufacturers Association held at the Edgewater Beach Hotel in Chicago on November 15 and 16, a definite program of future activity was outlined which will probably require several years to complete due to its broad scope and difficult problems to be undertaken for investigation and application.

The Association recognizes the constant increasing activity in the bituminous coal industry to improve its product for stoker application and plans to cooperate with the industry, in connection with the application of available coal sizes to stokers and development of stokers for the coals available for steam generation. The Engineering Committee recommended and received unanimous approval of the Association to review the Midwest Stoker Association setting heights standards for steel boilers. The old standards were adopted some 5 yr. ago and will be revised in the light of improved practice and experience.

Standardization of stoker sizes will be promoted and an attempt will be made to seek improved reports on stoker sales and production on data furnished to the Bureau of Census. These changes are approved by the Census Bureau but no action will be taken until the industry can furnish data on the new basis for the past 5 yr. so that the reports will be comparable.

At the closing session of the convention, officers for the coming year were re-elected. These include: President, J. R. Whitehead, Fairbanks, Morse & Co.; vice-president, R. B. McClave, McClave-Brooks Co.; treasurer, H. H. Kurtz, Iron Fireman Mfg. Co.; secretary, Marc G. Bluth.

Steel Alloy Exhibition Opens at Metal Products Exhibits, Rockefeller Center, New York

AN EXHIBITION of alloy steels is now being held at Metal Products Exhibits, the permanent exhibition of metals, alloys, plastics, and finishes in the International Building, Rockefeller Center, New York. The display, which was arranged under the direction of Adolf Bregman, Managing Editor of "Metal Industry," includes the products of 21 American manufacturers of steels and alloys. The exhibit is open daily from 10 A. M. to 6 P. M. and is free to the public.

As shown by the numerous specimens on display, steel alloys can now be produced which surpass ordinary steel in any of its desirable physical properties—strength, toughness, hardness, ductility, resistance to oxidation, corrosion, and the action of chemicals, stability at high temperatures, electrical characteristics, and luster. More and more, it is evident, the modern metallurgist is producing steel alloys that are specially adapted for specific services, such as the massive valve levers for Boulder Dam, the blades for steam turbines, the parts of automobile and airplane engines, the rigging of ships, surgical instruments, electrical conductors and resistances, domestic utensils, and countless other applications.

Among the exhibitors are the following:

American Sheet & Tin Plate Co.—Stainless sheet for various purposes.

American Stainless Steel Co.—Stainless steel for cutlery and technological uses.

Babcock & Wilcox Tube Co.—Boiler tube alloys.

Climax Molybdenum Co.—Chrome-nickel-molybdenum steels for automobile engine parts, tools, and metal cutting.

Cooper Alloy Foundry Company—Variety of rough and polished stainless steel castings for engineering and architectural applications.

Wilbur B. Driver Co.—Alloys for radio tubes, electrical apparatus, and thermostats.

Driver-Harris Co.—Alloys for electrical resistors, radio tubes, and for services requiring heat resistance.

Duriron Co.—Durco alloys for chemical manufacturing equipment.

Firth-Sterling Steel Co.—Demonstrate their new "clover-leaf" ingots for casting tool steel.

Haynes Stellite Co. and Electro Metallurgical Co. (Units of the Union Carbide & Carbon Corp.)—Alloys containing calcium, silicon, columbium, chromium, manganese, tungsten, and zirconium for a variety of services including building decoration, marine fittings, automotive engine valves, valve seats, metal cutting tools, surgical and dental instruments, etc.

Hevi Duty Electric Co.—Alloys for the heating elements of electric furnaces for the heat treatment of metals and ceramics.

International Nickel Co.—Nickel steels for diesel engine parts, roller transmission chain, grinding burs, spanners, and domestic utensils.

Jessop Steel Co.—"Composite" steels for dies, hacksaw blades, shear knives, automobile construction, and refrigerator trays.

Ludlum Steel Co.—Silcrome stainless steel for various purposes.

Michigan Steel Casting Co.—Nickel and chromium alloys for heavy duty machinery exposed to high temperatures.

Rustless Iron Corporation of America—Chromium and nickel alloys for various purposes requiring a non-corroding metal of high tensile strength.

Steel & Tubes, Inc.—Welded Steel tubes electrical conduit, and Toncan iron boiler tubes.

The Calorizing Company—Calorized steels, surface alloyed with luminum for high temperature applications.

Titanium Alloy Mfg. Co.—Titanium alloys for various purposes.

Vanadium Corporation of America—High and low carbon vanadium, chromium, silicon, and titanium steels for machine construction and structural purposes.

Westinghouse Electric & Mfg. Co.—Alloys for radio tubes.

Boiler Inspectors Meet

IN NOVEMBER the Boiler and Pressure Vessel Inspectors of the state of Michigan held their annual meeting which was devoted primarily to the proper design, maintenance and inspection of high pressure and high temperature power boilers.

L. D. Betz of W. H. & L. D. Betz, gave an illustrated talk on water and its impurities and outlined the modern methods of treatment. The science has a long background of experience as the first record of water treatment was in 1390 B. C. when Moses purified the Bitter Waters of Marah by the use of the juice of the Carab Tree. Mr. Betz talked chiefly on the colloidal method of water purification by which the impurities in the water are made to bloc or coagulate and are then removed by filtration. Following this Henry Kreisinger of the Combustion Engineering Co. outlined the possible economies using high pressure steam and discussed the thermodynamics of high pressures and high temperatures.

Standard practice of the Detroit Edison Co. in regard to welded construction of high pressure steam lines were detailed by D. H. Corey of that company. Their spec-

ifications for this type of construction are even more rigid than A.S.M.E. Code specifications. They use a butt welded joint with interior backing rings and where the pipe is ¾ in. or more thick the welds are stress relieved by an electrical induction furnace. Temperatures from 1100 to 1200 deg. are used, the heat being applied one hour for each inch of pipe thickness.

Welding of course has been extensively applied to pressure vessels of recent years and O. R. Carpenter presented a detailed discussion on the non-destructive testing of welded boiler joints. These methods include exploring the joint by a superimposed magnetic field; using a stethoscope in connection with the hammer test; using a para-magnetic exploring coil; locating of minute cracks by the use of a microscope and X-ray testing. Machines for the latter method are capable of penetrating 5 in. steel plates. The technique of operation is simple but the machines are not portable so that they are used primarily for factory tests.

Additional work on caustic embrittlement along the lines of the work followed by Frederick G. Straub was presented by Dr. Richard Schneiderwand. One point brought out by the speaker was that silicates must be in solution to play an active part in caustic embrittlement. From this it may be inferred that the silicates have a catalytic action and unfortunately, most feedwater contains silicates. Fortunately, however, embrittlement is usually a slow development and should be detected by inspection before it reaches a dangerous stage so that suitable corrective methods may be applied.

Edison Medal Awarded to Lewis B. Stillwell

The Edison Medal for 1935 has been awarded by the American Institute of Electrical Engineers to Dr. Lewis B. Stillwell, "for distinguished engineering achievements and his pioneer work in the generation, distribution, and utilization of electric energy."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The medal will be presented to Dr. Stillwell during the Winter Convention of the American Institute of Electrical Engineers to be held in the Engineering Societies Building, New York, N. Y., January 28-31, 1936. Dr. Stillwell was born in Scranton, Pa., March 12, 1863. He was a student in the Latin-Scientific course at Wesleyan University, Middletown, Conn., 1882-84, and took a special course in electrical engineering at Lehigh University, Bethlehem, Pa.

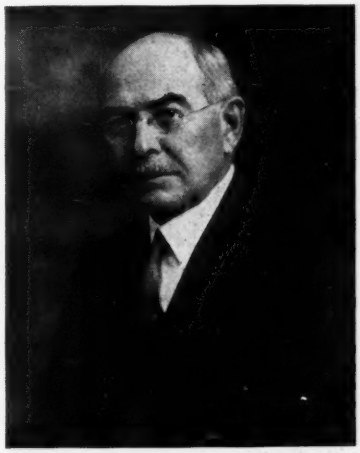
He was an outstanding leader in the development of alternating current, and had an active part in the determination of Westinghouse policy with respect to system development engineering and the establishment of 60 and 30 cycles as standard frequencies. Among his most important inventions are the "Stillwell Regulator," for the adjustment of voltage on outgoing lines; the "Time Limit Circuit Breaker," used to localize interruptions of service due to short circuits; and the "Diagrammatic Pilot-Control Switchboard," which is universally used to maintain before the operator a diagram of the power circuits as the main switches are opened or closed.

His contributions, as Westinghouse engineer, to the general layout and design of the first plant of the Niagara Falls Power Company, led to his appointment as Electrical Director of the latter company, which position he held from 1897 to 1900.

Mr. Stillwell began his practice as a consulting engineer in New York City in 1900, and has filled engagements with many companies on large and important engineering projects, including: the electrification of the elevated lines of the Manhattan Elevated Railway Co., 1900-06; Rapid Transit Subway Construction Co., 1900-09; Hudson and Manhattan Railroad, 1905-13; Wilkes-Barre and Hazelton Railway, 1902-05; Erie R.R. Electrification, 1906; United Railways and Electric Co., Baltimore, 1906-20; Interborough Rapid Transit Co., 1909-20; electrification of Hoosac Tunnel of New York, New Haven, and Hartford Railway Co., 1910-11; New York, Westchester, and Boston Railway Co., 1911-15; Lehigh Coal and Navigation Co., 1912-18; New York Municipal Railway Corp., 1913-16; the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission, in connection with the Holland Vehicular Tunnels, 1924-27; and Port of New York Authority since 1927.

Death of E. W. Rice, Jr.

Edwin Wilbur Rice, Jr., 73, honorary chairman of the board of directors of the General Electric Company, died at his home in Schenectady, N. Y., November 25 after a long illness. He was one of the pioneers of electrical development in the United States, and in asociation with the late Charles A. Coffin played a conspicuous part in the building of General Electric. He was largely instrumental in adding to the company's technical staff the late Charles P. Steinmetz; he encouraged the investigation by the company of the Curtis steam turbine and gave it a fair trial through a period of uncertainty until it became the foundation of a vast electric power system development; and he was chiefly responsible for the establishment of the famous General Electric research laboratory, having recommended that step to the directors in 1900.



Born in LaCrosse, Wisconsin, on May 6, 1862, he moved to Philadelphia where, as a school boy in 1876 he came into contact with Professor Elihu Thomson, then a teacher in Boys' Central High School. His natural fondness for mechanics and later for electricity was quickly developed by this association and when, in 1880, the professor gave up teaching to go into electrical manufacturing, as scientist and inventor, young Rice gladly accepted an opportunity to become his assistant. He went to New Britain, Connecticut, and for three years was with Thomson in the American Electric Company there and in Philadelphia, engaged in the manufactur of arc lamps and dynamos. In 1883 he went with the professor to Lynn, Massachusetts, upon the organization of the Thomson-Houston Company, when a majority interest of the American Electric Company was purchased by the

former concern. At the age of 22 he was made plant superintendent and had this full responsibility until the consolidation of Thomson-Houston and Edison General Electric in 1892 to form the present General Electric Company.

In the new company Mr. Rice was first made technical director, and in 1896 vice president in charge of manufacturing and engineering. He eventually became senior vice president and in 1913 he succeeded Mr. Coffin as president of the company. In 1922, after nine years of service in that office, he was succeeded by Gerard Swope, and was made honorary chairman of the board.

He contributed much through organization methods, improved factory routine, technical development, and engineering and scientific inventions to the pre-eminence attained by General Electric, having more than a hundred patents to his credit.

Their range is so wide as to embrace practically the entire field of electrical operations because in his position he consulted with the entire engineering staff and assisted in every form of engineering development which was going forward over a long period.

Mr. Rice's home since 1894 was in Schenectady, where he was a trustee of Union College. He held A.B. and A.M. degrees from Central High School, Philadelphia; an honorary A.M. from Harvard, 1903; a D.Sc. from Union University, 1906; a D.Eng., from Rensselaer Polytechnic Institute, 1917; and a D.Sc. from the University of Pennsylvania. He was a Chevalier of the Legion of Honor, and was decorated with the Third Order of the Rising Sun by the Emperor of Japan in 1917. Mr. Rice was president of the American Institute of Electrical Engineers in 1917, from which organization he received in 1931 the Edison Medal "for his contributions to the development of electrical systems and his encouragement of scientific research in industry."

He was a member of the Institution of Civil Engineers, England, of the English Institution of Electrical Engineers, and of the Society of Illuminating Engineers. He was a director of the General Electric Company, the International General Electric Company, Electric Bond and Share Company, British Thomson-Houston Company, Ltd., the Schenectady Trust Company, the Detroit Edison Company, and for many years of the Radio Corporation of America.

World Power Conference

DURING THE WEEK of September 7 to 12, 1936, the Third World Power Conference and the Second Congress of the International Commission on Large Dams will be held concurrently in Washington, D. C., under the auspices of the Federal Government. The executive organization has been completed and includes the following:

Honorary President — Franklin D. Roosevelt, President of the United States; Honorary Vice-President and Chairman of the American National Committee—Harold L. Ickes, Secretary of the Interior; Chairman of the Conference and Vice-Chairman of the American National Committee—William F. Durand, Palo Alto, Calif.; Chairman of the Executive Committee—Morris L. Cooke, Rural Electrification Administration; Director—O. C. Merrill, consulting engineer, Washington, D. C.; Executive Secretary—Joel David Wolfsohn, National Power Policy Committee, Interior Building, Washington, D. C.

Executive Committee — Chairman, Morris L. Cooke; C. W. Appleton, vice-president General Electric Company; Floyd L. Carlisle, chairman of board Niagara Hudson Power Company; Frank D. Comerford, president Edison Electric Illuminating Company, Boston; Gano Dunn, president J. G. White Engineering Corporation; Robert H. Fernald, dean Towne Scientific School, University of Pennsylvania; A. C. Fieldner, chief engineer Experiment Station Division, Bureau of Mines, Washington, D. C.; Daniel C. Green, trustee Middle West Utilities Company; David E. Lilienthal, director Tennessee Valley Authority; William McClellan, president Potomac Electric Power Company; Frank R. McNinch, chairman Federal Power Commission; Gen. Edward M. Markham, Chief of Engineers, War Department, Washington, D. C.; O. C. Merrill, consulting engineer, Washington, D. C.; I. E. Moultrop, consulting engineer, Boston, Mass.; T. W. Norcross, chief engineer Forest Service, Department of Agriculture, Washington, D. C.; Richard Southgate, Chief of Protocol, State Department, Washington, D. C.; C. E. Stephens, vice-president Westinghouse Electric & Manufacturing Company, and Joel David Wolfsohn, executive secretary National Power Policy Committee, Washington, D. C.

The executive committee will be in active charge of the planning and carrying out of the conference, subject to the general direction and approval of the American National Committee, which will be composed of the executive committee and approximately 80 additional representatives of the utilities, including coal, oil and gas producers, the professional societies and others.

An outline of the program under the general title, the National Power Economy includes seven sections as follows: Section I, Physical and Statistical Basis of the National Power Economy, Technical, Economic and Social Trends; Section II, Organization of the Fuel Industries; Section III, Organization and Regulation of Electric and Gas Utilities; Section IV, National Planning for most Efficient Utilization of Natural Resources; Section V, Problems in Regional Planning; Section VI, Rationalization of Distribution; Section VII, National Power and Resources Policies.

Technical Program for the A.I.E.E. Winter Meeting

The technical program for the A.I.E.E. winter convention which will be held in the Engineering Societies Building, New York, N. Y., January 28-31, 1936, is, as usual of broad scope and timely interest. The convention will convene on a Tuesday and technical sessions will be held both morning and afternoon for the first three days. Wednesday evening the Edison Medal presentation will take place and on Thursday evening the dinner dance will be held at the Hotel Plaza.

Thirteen technical sessions and one electrical conference have been scheduled to bring forth a number of developments in specialized fields. Several of these papers are of international importance, particularly the adoption of the International Electrotechnical Commission of the meter-kilogram-second system of units, the story of which will be told by Dr. A. E. Kennelly. Also two papers from France will treat the developments in the electrotechnical and electrometallurgical industries in that country. One of these papers will describe the electric furnace with the carbon radiator which has been perfected in France.

Another group of papers sure to be of outstanding interest will be presented in the protective devices session. Several of these papers will present data obtained from

this year's lightning season in various sections of the country. Data will be included on lightning arrester performance and the protection of distribution transformers, some of it the first presented in respect to the interconnection of primary and secondary neutrals.

At 1 or 2 other sessions and the conference on electric welding, demonstrations of electrical phenomenon by means of high speed motion pictures will play an important part. The latest design practices in the development of synchronous machinery as well as recent studies in commutation will be presented at two sessions on electrical machinery.

In a session on Communication, A. H. Lamb of the Weston Electrical Instrument Co. will present a paper on applications of the photoelectric cell. Anode materials for high vacuum tubes will be discussed by E. E. Spitzer of R.C.A. Manufacturing Co., Inc.

A session on Instruments and Measurements will include a paper by H. E. Edgerton on High Speed Motion Pictures, and one by L. A. Doggett and H. I. Tarpley on Power and Energy.

A Power Transmission session on Wednesday, January 29, will consider a number of varied power problems. E. A. Church of the Edison Electric Illuminating Co. of Boston will present a paper on the economical loading of underground cables. Corona losses at 230 kv. with one conductor grounded will be the subject of a paper by J. C. Carroll of Stanford University and D. M. Simmons of the General Cable Corp.

Other sessions will be devoted to Electrophysics, Magnetic Materials, Automatic Stations, Transportation, Protective Devices and Modernization of Distribution Systems.

Friday, the last day of the convention, will be devoted exclusively to inspection trips to interesting places in the city and vicinity.

IN ORDER to make visible the difference in gear noises between laminated bakelite gears and metal gears, the Synthane Corp. of Oaks, Pa., developed a device called the Synthane Noisometer which was exhibited for the first time at the Machine Tool Show in Cleveland. This device consists of a cathode ray oscillograph and a train of spur gears arranged so that either a Synthane laminated gear or a steel gear can be thrown in mesh. Noises are reproduced as a pale green line on the screen of the cathode ray tube, the amplitude of the wave being a measure of the noise.

News From the Field

EARLE W. MCMULLEN recently became Director of Research of the Eagle-Picher Lead Company, the post formerly held by Dr. John A. Schaeffer who resigned to become president of Franklin and Marshall College. Mr. McMullen, who is well known in this industry for his work in this field and for coöperation with various engineering and technical associations, graduated from Armour Institute in 1909. He has been an instructor in metallurgy at Armour Institute and has for many years been identified with the research field through his connection with the Simmons Co. and Celotex Co.

PENNSYLVANIA PUMP & COMPRESSOR Co., Easton, Pa., has appointed G. G. Van Tuyl, 18927 Winslow Road, Cleveland, as its representative in the Cleveland district.

ALL ASSETS AND OPERATIONS of the Pierce, Butler & Pierce Mfg. Corp. have been transferred to the new Pierce Butler Radiator Corp., 701 Nichols Ave., Syracuse, N. Y. The new corporation will continue to manufacture, sell, distribute and service all products of the former corporation as well as a new line of products being marketed for the first time.

CUTLER-HAMMER, INC., Milwaukee, Wis., announces the advancement of G. S. Crane, sales manager, and W. C. Stevens, chief engineer, to vice-presidencies in charge of sales and engineering respectively. Mr. Crane, a graduate of the University of Michigan, has been with the company more than 25 years and Mr. Stevens, a graduate of Cornell University, over 30 years, both men having experience in both the sales and engineering departments.

THE AMERICAN DISTRICT STEAM Co. of North Tonawanda, N. Y., announces the appointment of Edward A. Hahl to the Sales Engineering Staff. Mr. Hahl is prominently known in the water heater and heat interchange equipment field where he has been active for the past fourteen years and he will continue to specialize in this field with the American District Steam Co.

ANNOUNCEMENT is made of the twelfth National Oil Burner Show to be held at Convention Hall, Detroit, Mich., April 14 to 18 inclusive. G. Harvey Porter is managing director of Oil Burner Institute with headquarters at 30 Rockefeller Plaza, New York. Exhibitors will include burner manufacturers, accessory manufacturers, oil companies, and other related displays.

FOURTH INTERNATIONAL HEATING & VENTILATING EXPOSITION will take place Jan. 27-31 at the International Amphitheater in Chicago.

THE TIMKEN STEEL & TUBE Co. of Canton, Ohio, recently issued loose leaf data sheets on Sicromo Steel as a supplement to the Timken High Temperature Digest.

THE EASTERN STEAM Specialty Co., Inc., 125 Barclay St., New York City, has been named New York representative for The McAlear Mfg. Co., of Chicago, Ill.

DIAMOND POWER SPECIALTY CORPORATION announces the removal of their Chicago office from 20 North Wacker Drive to Suite 1422—Bankers Building, 105 West Adams Street.

GENERAL REFRACTORIES Co. announce the appointment of The Bird-Archer Co., Philadelphia, Pa., as dealer agents in the Philadelphia area.

ALFRED HEBER MCINTIRE, who for twenty-three years was Editor and Manager of The Electric Journal, died of pneumonia at his home in Pittsburgh on Monday, November 4. Mr. McIntire was born August 13, 1876. He received the degree of E.E. from Ohio State University in 1898; and the degree of M.E. from O. S. U. in 1900. An extensive experience with the manufacture of Corliss engines, with an electric railway company, with an electrical contractor, as well as test floor experience with both General Electric & Westinghouse companies, gave him a broad background for his editorial work. He became the first full-time editor of The Electric Journal in 1906, shortly after its inception; and, in 1908, was appointed Editor and Manager, which position he held until 1931. He is survived by his wife, Clara Hudson McIntire; and by two children, Mrs. Edith Helen Ailes, who resides in San Francisco, and Heber Richards McIntire of Dallas, Texas.

THE BABCOCK & WILCOX Co. announces that the Refractories Division Sales Office for the Southeastern District has been transferred from Atlanta to the Works at Augusta, Georgia.

REPUBLIC STEEL CORP., Youngstown, Ohio, announces the following appointments in its sales organization: Paul R. Johnston has been named district sales manager in the Cincinnati, Ohio, territory, succeeding Robert J. Working, recently appointed district sales manager at Birmingham, Ala. Charles W. East, formerly of the Birmingham, Ala., office, has been named assistant manager of sales in Republic's Pipe Division, succeeding George E. Clifford, recently appointed district sales manager for Republic in the Los Angeles, Calif., territory. C. A. Cherry has been appointed district sales manager in the Buffalo, N. Y., territory. Mr. Cherry replaces Thomas B. Davies, who has been transferred to Republic's Alloy Steel Division in Massillon, Ohio, as special representative. Robert J. Working has been appointed district sales manager in the Birmingham, Ala., territory, succeeding Kenneth D. Mann, who has resigned to become executive vice president of the Truscon Steel Co.

AIR HYGIENE FOUNDATION of America, Inc., has been formed by a large group representing various industries with headquarters at Thackeray Ave. and O'Hara St., Pittsburgh, Pa. The purpose of this organization is to conduct investigations of and to stimulate research on problems in the field of air hygiene and to gather and disseminate factual information relating to this subject. The Mellon Institute of Industrial Research is coöperating with this new organization and is now investigating the technological and economic aspects of air contamination. H. B. Meller has been appointed managing director of the foundation and will head the investigation at Mellon Institute.

ALBERT C. WOOD and Alton Kirkpatrick have announced the opening of consulting engineering offices under the name of Wood and Kirkpatrick in the Stock Exchange Bldg., 1411 Walnut St., Philadelphia, Pa.

For the Engineer's Library

STEEL PLATES. 362 p., 6½ by 9¼ in., fabrikoid cover. Bethlehem Steel Co., Bethlehem, Pa. Price $1.00.

The subject is technically though simply treated to show the manufacture and various applications of steel plates and give a reference book for designers, engineers and fabricators on the details of tanks, cars, boilers, buildings and the like. It is designed to give in a single volume all necessary working data, with tables, specifications and metallurgical information. Five main divisions are correllated: Part I is on manufacture, specifications data and specifications; Part II deals with flanged and dished heads; Part III covers tubes; Part IV is concerned with boiler design, riveting and welding; Part V includes engineering tables such as functions of numbers, trigonometric functions and the like. Blank cross-section sheets provide space for added data and sketches and a full index makes reference convenient.

POWER PLANT CHEMISTRY. By Augustus H. Gill, Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Size 5½ by 8½ in., 207 pages, cloth bound. Price $2.50.

This is the fourth edition of a practical book written primarily for the power plant operator, and formerly known as Engine Room Chemistry. The present edition has been considerably enlarged and now covers general discussion of elementary chemistry, apparatus and chemicals necessary for simple tests, fuels and their analysis, gas analysis, combustion, pitting and corrosion, oils and various types of greases. The appendix contains a number of tables and charts of valuable and practical data.

PROCEDURE Handbook of Arc Welding Design and Practice. 6 by 9 in., 586 pp. Flexible fabricoid. Price $1.50, postpaid. The Lincoln Electric Co., Cleveland, Ohio.

Encyclopedic in scope and contents is the new handbook which is divided into eight principal sections, each dealing with an important phase of arc welding. Simple, concise text and over 700 illustrations consisting of detailed drawings and photographs cover practically every use and application of arc welding.

New features of this revised and enlarged edition include the following: American Welding Society specifications for filler metal; method of determining the amount of current carried by the electrode; procedures, speeds and costs for making all types of welds in sheet metal; A.S.M.E. Boiler Code requirements for butt welds in heavy plate; hard facing of ferrous metals; examples of redesigning for arc welding; use of arc welding in making and repairing cutting tools and dies; speed of welding oil and gas pipe lines. The book was written especially for the use of designers, engineers, welding supervisors and operators, yet serves as a practical guide to all who are interested in arc welding, and as a handy reference for estimating welding costs.

The eight sections of the book cover: I. Welding Methods and Equipment; II. Technique of Welding; III. Procedures, Speeds and Costs for Welding Mild Steel; IV. Structure and Properties of Weld Metal; V. Weldability of Metals; VI. Designing for Arc-Welded Steel Construction of Machinery; VII. Designing for Arc-Welded Structures; VIII. Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance. Part IX is devoted to advertising of equipment for arc welding.

A SYMPOSIUM ON ILLUMINATION. Edited by C. J. W. Grieveson. First Edition. Cloth, 5½ by 8¾ in., 229 pages, illustrated. Published by Instruments Publishing Co., Pittsburgh, Pa., 1935. Price $4.50.

This book is a reprint of a series of lectures given in the spring of 1933 under the auspices of the National Illuminating Committee of Great Britain and the Illuminating Engineering Society at the Regent Street Polytechnic in London. It deals with the diverse theoretical and practical problems connected with modern lighting. These problems are so varied that their adequate presentation would have been difficult for any one lecturer, so a number of specialists were invited to give these lectures. The book, therefore, consists of ten chapters, each one written by an expert in the particular subject with which the chapter is concerned. In the order in which they appear these chapters are as follows:

1, Lighting in the Service of Mankind, by Clifford C. Paterson; 2, Radiation: Light and the Eye, by J. W. T. Walsh; 3, Electric Lamps and Their Characteristics, by W. J. Jones; 4, Gas Lamps and Their Characteristics, by F. C. Smith; 5, Daylight: Colored Light, by J. W. T. Walsh; 6, Photometric Standards, Lamp Photometry, and Illumination Measurements, by J. T. Macgregor-Morris; 7, The Redistribution of Light, by G. H. Wilson; 8, Lighting for Decoration and Entertainment, by A. B. Read; 9, Public Lighting, by J. F. Colquhoun; 10, Lighting for Safety, Health, and Welfare, by H. C. Weston.

The English point of view from which these chapters are presented should not detract from their interest to American readers.

GRAPHIC COURSE OF PATENTABLE INVENTIONS. By H. A. Toulmin, Jr. Published by D. Van Nostrand Co., Inc., 250 4th Ave., New York, N. Y. Size 6 by 9 in., 40 pp., cloth bound. Price $1.

This book gives a simple and logical exposition of the three major steps in the life of an invention beginning with the development, testing and completion of the idea; protection of the invention, and enforcement of the patent in the courts. The various steps are presented in graphic form, with numbered explanatory paragraphs in simple language to give the inventor a definite and concrete idea of the complicated legal process of the patent procedure, but no attempt has been made in the book to provide a manual and make a lawyer out of the layman.

DIESEL ENGINEERING HANDBOOK. Edited by L. H. Morrison. Published by Diesel Publications, Inc., 192 Lexington Ave., New York, N. Y. Size 6 by 9 in., flexible fabricoid binding, 824 pp. Price $5.00.

Perhaps no field of engineering is better covered by recent books than that of the Diesel and it would seem that a new book must of necessity be mere repetition. It is, therefore, a pleasant surprise to find that the arrangement, composition and printing of this, the eighth or de luxe edition, lives up to the advance claims and justifies a prominent place in Diesel literature. The size is more convenient than the previous edition and the few poor illustrations which marred that edition are not evident in the new one.

Handbook is hardly the proper word to do justice to the contents of the book. Rather it is a comprehensive text on the construction, operation and maintenance of the Diesel engine, well illustrated, well presented and clearly written. After a brief historical resume of internal combustion engines and fundamental principles, each type of engine and various parts of the engine such as fuel injection systems, frames and cylinders, valves and gears, fuel pumps and nozzles, speed governors, etc., are dealt with in detail in separate chapters.

Several chapters are devoted specifically to operation and maintenance but practical operating information is scattered throughout the book in the chapters devoted to the various engine parts. Approximately 85 pp. are devoted to the use of the Diesel in the truck, tractor, rail and aviation service.

STANDARD PRACTICES, published by the Diesel Engine Manufacturers Association. Printed and distributed by Diesel Publications, Inc., 192 Lexington Ave., New York City. Size 6 by 9 in., 156 pp., cloth bound. Price $2.

This is an amplification of the standards published by the Association 5 yr. ago. It covers definitions, performance, a short analysis of the A.S.M.E. Diesel engine cost reports, give detailed directions for the selection of engine sizes, building construction, operation and maintenance, with suggestions for the preparation of bids and detailed specifications. Suggestions regarding necessary equipment, auxiliary, oil storage and water cooling layouts are particularly valuable representing as they do the combined experience of some 16 member companies.

RESULTS OF MUNICIPAL LIGHTING PLANTS, Fourth Edition, has been published by Burns & McDonnell Engineering Co., Kansas City, Mo. This is a compilation of record from 415 cities under municipal ownership with rates in effect in 1934 and 1935. It is a 182 page paper bound volume, 6 by 9 in., and sells for $1.

GENERATING STATIONS. Economic Elements of Electrical Design. By Alfred H. Lovell. Second Edition. Size 6 by 9 in. Cloth, 438 pages, illustrated. McGraw-Hill Book Co., Inc., New York, N. Y., 1935. Price $4.50.

There are a great many more books available on the technical aspects of generating station design than there are on the economic side; indeed, there is a scarcity of good material dealing with the economic considerations of power plant work. Mr. Lovell's book, therefore, meets a distinct need and his presentation of the subject should be of interest not only to designers, but to operators as well. A considerable part of the book is devoted to a discussion of the determination of power costs and the economics of power plant operation. Perhaps the best idea of what the book contains is to list the chapter headings. These are as follows: 1, Elementary Principles of Corporate Finance; 2, Cost of Stations; 3, Economic Decay; 4, Power Plant Load Curves; 5, Economic Conductor Section—Power Distribution Systems; 6, Power Plant Location; 7, Bus

Systems and Current Limiting Reactors; 8, Oil Circuit Breakers and Their Application; 9, Introduction to Single Phase Short Circuits; 10, Protective Relays and Their Applications; 11, Transmission Lines with Synchronous Condensers.

BOILER-WATER TROUBLES and Treatment with Special Reference to Problems in Western Oregon by R. E. Summers, Bulletin Series No. 5, May, 1935, published by the Engineering Experiment Station, Oregon State Agricultural College, Corvallis, Ore.

This pamphlet prepared especially to aid engineers in the treatment of their boiler water is divided into nine parts, including the introduction; the importance of the problem in western Oregon; peculiar and unusual boiler-water conditions in western Oregon; boiler ills and their causes; water treatments used in boiler plants, their advantages, their limitations; possibilities of rational boiler-water treatment in western Oregon; summary of conclusions, acknowledgments, and bibliography. The whole subject is treated in very condensed form, with many charts and tables, and should prove of considerable value to engineers in power plants not only in Oregon but throughout the entire country.

A FUGUE IN CYCLES AND BELLS, by John Mills. First Edition, cloth, 264 pages, illustrated. Size 5½ by 8¼ in. Published by D. Van Nostrand Co., New York, N. Y., 1935. Price $3.00.

It may seem strange and somewhat unorthodox to present a review of a book on "music" in the pages of a power plant magazine. This book, though it deals with music, is different, however, from all other books on music in that it discusses the subject from an electrical or shall we say an engineering viewpoint and that is the reason for our interest here. For electricity has been doing strange things to music in recent years and, from this book, it is quite apparent that we "ain't seen nothin' yet." Indeed, what has been done is only an indication of the greater things which are to follow.

To those who know the author, this book needs no recommendation. Those who have read his fascinating "Within the Atom" his "Letters of a Radio Engineer to His Son" and other books need no introduction to his refreshing style of writing, his keen sense of humor and his remarkable knack of explaining complex matters in simple language. And this book, if anything, is John Mills at his best. Here he tells about what electricity is doing for music. In his clear and engaging style he discusses recent investigations on the ear's ability to perceive musical sounds; and then to what the ear can hear he relates what electricity can do. It is a book for the layman—for the person who has not followed the enormous development of the communication art or the researches of the Bell Telephone Laboratories. It is a book as intriguing as its name. Vividly portrayed is the great field of the future, the application of the electrical art to music itself. The book offers everybody the opportunity to gain a full understanding of this great and important prospect by spending a few hours of most interesting reading.

Mr. Mills is well qualified to write this book. For many years he has been a member of the technical staff of the Bell Telephone Laboratories. He is a Fellow of the Institute of Radio Engineers and of the American Physical Society and is well known as an engineer and an inventor. He has over a score of patents to his credit.

INDUSTRIAL ELECTRONICS. By F. H. Gulliksen and E. H. Vedder. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Size 6 by 9 in., cloth, 239 pp. Price $3.50.

Electronics opened up an entirely new and astonishingly accurate method of control and regulation, ideally suited to industrial conditions. Progress in application has been reasonably rapid but has lagged behind that expected by those familiar with its possibilities. The reason for this rests mostly on those same people who early showed a tendency to put it before the public as a branch of black magic. However much an engineer may be impressed by this sort of thing he is not apt to turn to it as a practical method of solving his problems.

Now electronics is and probably always will remain in the hands of specialists as do instruments and control equipment of all kinds, but there is nothing magical about the electronic tube. It is an industrial tool capable of unlimited application, simple in its fundamental concept and easily reproduced.

The authors, from the background of their experience with Westinghouse, have set about dispelling the magic by showing how simple and practical the subject can be made. Part I of the book deals with the properties of the three types of industrial tubes, the light sensitive, the high vacuum, and the gas filled types. Part II deals with the fundamental circuits with which the tubes are used, and Part III, the application of the cells and circuits as instruments and control equipment. In this section equipment representative of each type of application is described in detail. Part IV covers the practical application to regulators of different kinds such as voltage, speed, register, process and temperature.

With the exception of Part I, which is too brief because as the authors point out, it has been covered previously in a thorough manner (Electronic Tubes by Morecroft; John Wiley & Sons, price $4.50) the book is comprehensive and covers industrial applications well.

INTRODUCTION TO ELECTRICAL TRANSIENTS, by Edwin B. Kurtz and George F. Corcoran, first edition; size 6 by 9; 335 pages; illustrated; cloth. Published by John Wiley & Sons, Inc., New York, 1935. Price $4.50.

This is an unusually excellent book. Though it is designed primarily for the student and for class use, it should be equally valuable to the engineer who wishes to refresh his memory on the subject or who never really understood the subject before. For the subject of electrical transients has always been a rather formidable one and the engineers that really do understand it are few and far between. Yet electrical transients are very necessary to a proper understanding of electrical circuits and this book explains the fundamentals as clearly and as thoroughly as anything that we have ever seen.

The steady-state solution of a circuit problem which usually constitutes a major part of the work in the electrical engineering course is only one part of the complete solution and unless one is familiar with what goes on immediately after the establishment of the circuit, currents and potentials, one does not have a true picture of the electric circuit as a whole. After the circuit is completed and potentials applied a certain lapse of time is required for the electrical conditions to adjust themselves to their ultimate steady-state modes of variation. This time interval is called the transient period and it is with the happenings that occur in this time interval that this book is concerned. The material in it ranges from simple circuit configurations to the more complex for both a.c. and d.c. conditions. Actual oscillograms accompany all the major discussions and analyses. The subject of power transients has been given a prominent part in the text. The method of presentation employed is to consider each type of transient under three distinct headings: 1. Physical considerations under which the reader can analyze the physical aspects of circuit conditions in terms of basic principles and laws with which he is familiar. 2. Mathematical analysis under which, given the fundamental equilibrium equations, the results are derived in accordance with the laws of conventional mathematics. 3. The question of oscillographic verification.

The valuable part of the book is the mathematical appendix. This is written particularly for the student who is familiar with the elementary calculus but who has not yet taken a formal course in differential equations or other advanced mathematical courses. Heaviside's operational calculus, which is used in the solution of some of the problems, also forms part of this mathematical appendix.

ELECTRICAL MEASUREMENTS IN PRINCIPLE AND PRACTICE, by H. Cobden Turner and E. H. W. Banner. First edition; cloth; size 5⅛ by 8¼ in.; 380 pages; illustrated. Published by Instruments Publishing Co., Pittsburgh, Pa., 1935. Price $4.50.

This book was written with the object of supplying concise information on the more usual electrical instruments, principally to those who only occasionally have to make electrical tests. For this reason much of the subject matter is dealt with in an elementary way. While there are various text books dealing with the theory of measurements and others dealing with measuring instruments, these usually treat with the subjects from the specialists point of view. The object of the present book is to give a general account of almost all types of electrical measurement suitable to those engineers and others who have to make such measurements relatively infrequently and who do not require a text book involving such mathematics as are only essential to the student and research worker. The book also should prove of value as a reference on electrical measurements to all electrical engineers.

WORKED EXAMPLES IN ELECTROTECHNICS, PART I. By H. Turner Aspinall. The Engineer's Book Shop, 168 E. 46th Street, New York City. Size 5 by 7 in., 140 pp., cloth bound. Price $1.75.

A person may read or study indefinitely on a particular subject and yet without application the knowledge remains in a nebulous and more or less useless state. This little book is the application or laboratory course for the practical application of magnetism and electricity and consists entirely of worked out problems. The 111 problems cover the entire range from Ohm's law through series and parallel circuits, magnetism, induction, instruments and d.c. motors and generators. The problems will be found surprisingly practical and the answer to many an every day calculation to those having anything to do with electricity. Parts II, III and IV covering direct current machines, advanced a.c. circuits and a.c. machines will follow. In addition to the problems there are tables of logarithms and a detailed explanation of their use in order to facilitate calculation for those not equipped with slide rules. There are also several pages of definitions of electrical quantities and formulae and in addition 94 questions selected from past National Technical Examinations for Electrotechnics examinations and for the Mechanical and Electrical Engineers Certificate of Competency (So. Af-

rica). Reader should not be scared by the imposing title which means, in this case, nothing more or less than the practical application of elementary electricity.

REDUCING INDUSTRIAL POWER COSTS. By David Moffat Myers. 378 pp., 6 by 9 in., Cloth, 1935. McGraw-Hill Book Co. Price $4.

As stated in the preface, this book is intended to give in non-technical language what every executive ought to know about the highly technical subject of power production and its use and the cost of power. Why power cost should have attention is indicated by the fact that it may run from 50 to 75 per cent of the amount paid in dividends and this power cost may, by modernization of operation and equipment, often be reduced by 30 per cent, thus increasing the amount available for dividends by some 20 per cent, which is much worth while. Compared to increase of sales, a dollar of sales lost means only 10 to 20 cents lost in dividends, but a dollar lost in power costs is all lost.

Listing 100 possibilities for improvement, the subject is divided into design and operation and the need discussed of having the assistance of an engineer with an outside viewpoint, since the operator of the plant is likely to be loaded down with routine duties so that he may overlook the possibilities for better operation and for profitable rehabilitation. Also the wisdom of paying salaries in the plant that will secure most intelligent operation is stressed.

As to water power versus steam power, the discussion of George A. Orrok is included in Chapter XXI to give a comprehensive view of the economics of this much misunderstood question. A review of the various methods of treating boiler feedwater for impurities is followed by a long chapter on the Power-loss Check Chart, which summarizes all the points where power may be lost and discusses the methods of checking to determine what the loss is at each point and what may be done to reduce it. The final chapter is devoted to a resume of power facts and data, largely taken from census reports, to show the amount of each kind of power used in the country and give an idea of the great savings that can be accomplished by reduction in power costs.

This book is well adapted to do what it was intended to do and the author, from his years of experience in the field is eminently fitted to write it. Every executive who reads it and applies the knowledge gained, or is influenced to allow his engineers to apply the knowledge that they have, will be well rewarded by the economy that will be accomplished in the operation of the plant under his charge.

INSTRUCTIONS FOR OPERATING LARGER AMMONIA MACHINES is the title of a 30 page, 8½ by 11 in. bulletin, No. 131 F, published by the Frick Co., Waynesboro, Pa.

This is a detailed instruction book prepared and sent out with Frick compressors to assist in the proper installation, operation and maintenance of refrigerating plants so as to obtain the utmost economy and service from the compressors. Although the illustrations used refer specifically to Frick machines, the book will prove a valuable guide to any one having charge of the installation or operation of refrigerating machinery.

The book covers conditions and questions that are likely to come up in every day practice; is written in simple language without technical phraseology. Contents include a brief discussion of the principles of refrigeration, preparation of foundations, arrangement of equipment, piping, starting a compressor, testing and charging the system, removing ammonia from different parts of the system, lubrication, removal of air and non-condensible gases, care and adjustment of compressors and general instructions for operating the plant. In the back are a number of tables of pipe dimensions, properties of different brine solutions, properties of ammonia, storage temperatures and other useful data.

STEAM PLANT OPERATION. By E. B. Woodruff and H. B. Lammers. Published by McGraw-Hill Book Co., New York City. Size 5½ by 8½ in., cloth bound, 341 pages. Price $3.

With modern plants and improved methods of operation, the responsibilities of the operating engineer are increasing and his responsibility for the safe and efficient operation of the plant cannot be over emphasized. The discharge of his duties require a considerable theoretical as well as practical knowledge and it is the aim of the authors of this book to present to the readers approved methods of operating all equipment usually found in the power plant, to give clear and concise methods of operation and to depict the progress and development in this field. The book is, therefore, a combination of technical and practical information. The practical problems are solved without the use of involved mathematics and suitable for study by those having only a grammar school education.

The authors are both licensed stationary engineers, one plant engineer and the other test engineer with the Union Gas & Electric Co. and both instructors in the Ohio Mechanics Institute.

From the brief introduction dealing with the plant as a whole, steam boilers of different types, combustion, furnaces, boiler accessories and operation and maintenance are covered in considerable detail in the first 166 pages of the book. Prime movers, including steam engines and turbines, their construction and operation, are covered in the next 116 pages. Pumps of all types have a separate 28 page chapter and auxiliary power plant equipment, including feedwater heaters, condensers, traps, separators, lubrication, power and insulation are crowded into a 30 page chapter. This is perhaps the only criticism of the book which could be justified.

THE HANDBOOK OF CHEMISTRY AND PHYSICS, 20th Edition, edited by Charles D. Hodgman. Size 4½ by 6¾, 1966 pages; bound in flexible fabricoid. Published by the Chemical Rubber Publishing Co., Cleveland, O., 1935. Price $6.

Among the many handbooks published, this is one of the most amazing. We venture to say that the material concentrated in the 1966 pages between the covers of this book represents a greater amount of mental and physical effort than can be found in a like space anywhere else. The amount of labor expressed in man hours or days or years involved in compiling the thousands of tables and charts and lists of chemical characteristics is incalculable. In it is crystallized the results of centuries of investigation and effort on the part of thousands of individuals, not only in chemistry but in physics as well. If one would be so presumptuous as to dare criticize a book of this type, the only thing that could be said is that it contains too much.

The book has been issued for 22 yr., each year it has been revised and its scope extended. Among the revisions in this new edition, the most important is the revision of the table of physical constants of organic compounds. The most important feature of this table is the Nomenclature worked out by Dr. Austin M. Patterson, vice president and professor of chemistry at Antioch College.

Among the other divisions of the book which have undergone revision, is the formula index of organic compounds comprising some 30 pages, the list of pronunciation of chemical words, the section devoted to the rules for naming organic compounds, the section devoted to X-ray Spectra and the section on colorimetry. This latter section has been revised and enlarged with the assistance of Mr. Frank Benford of the General Electric Research Laboratory and includes a number of useful tables including photometric quantities, units and standards, flame standards, efficiencies of illuminants, intrinsic brilliancy of light sources, wave lengths of various radiations, brightness of tungsten, coefficient of reflection of magnesium carbonate and reflection coefficients. The handbook is divided into five sections of approximately equal size, listed as follows: 1. Mathematical tables; 2. Properties and physical constants; 3. General chemical tables; 4. Heat, hygrometry, sound, electricity and light; 5. Quantities and units.

STICKLE STEAM SPECIALTIES CO., Indianapolis, Ind., has issued its bulletin No. 50 describing a new Stickle system that lowers operating costs and increases production efficiency. These results are secured through the use of Stickle Differential Drainage and boiler return systems of new design.

HANCOCK VALVE DIVISION of Consolidated Ashcroft Hancock Co., Bridgeport, Conn., is distributing two new bulletins, one describing the new Hancock Flocontrol valve and the other giving details of the new Hancock union bonnet bronze valve.

SPEED CONTROL HANDBOOK, a 5½ by 7½-in., 109 page, cloth bound book has recently been issued by the Reeves Pulley Co. of Columbus, Ind. This is a complete discussion of industrial speed control, particularly from a standpoint of Reeves variable speed transmission; shows how the equipment is used in various industries and gives detailed data on various standard units available.

THE JOHN WALDRON CORP., New Brunswick, N. J., is distributing a new catalog describing and illustrating the important changes which have recently been made in the Francke flexible coupling. In addition to describing the important changes in design and materials, the new catalog gives complete tables of sizes for the various types, full directions for size selection and coupling service factors.

ILLUSTRATING its varied lines Morris Machine Works, Baldwinsville, N. Y., has just issued Bulletin 157 covering centrifugal pumps, dredges and steam engines and including considerable information and data on the capacities and heads of centrifugal pumps and friction flow in pipes.

HORIZONTAL DUPLEX piston pumps, Carbondale refrigeration compressors and single stage centrifugal pumps are covered in recent bulletins issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

PUMPING OF WATER, oil and other fluids by the Air Lift is described in a recently issued 24 page booklet, Bulletin No. 9402, printed by Ingersoll-Rand Co., Phillipsburg, N. J.

SMOOT REGULATORS of the 50 (hydraulic) series and the 60 (pneumatic) series are described in detail in Data Book

No. S-11 issued by the Smoot Engineering Division of the Republic Flow Meters Co., 2240 Diversey Parkway, Chicago. As indicated by the name, the book is more than a catalog as it contains a brief discussion of the fundamental characteristics of a good regulator and application methods for the control of pressure, flow, level and speed. The way in which various elements of the Smoot regulator operate to meet these fundamental requirements is analyzed in detail and the complete cycle of an assembled regulator is shown by color plates. Application of the Smoot control system for boilers is covered in Data Book No. S-20 issued earlier in the year.

SLURRY AND SLUDGE PUMPS, especially adapted for liquids containing abrasive solids in suspension are described in Bulletin 207 published by the Lawrence Machine & Pump Corp., 371 Market St., Lawrence, Mass.

LINK-BELT Co., Philadelphia, has just issued catalog No. 1519 describing its line of single, double and triple reduction herringbone gear speed reducers for large speed ratios, and heavy and shock loads.

THE MUNICIPAL SMOKE PROBLEM is the title of a brief treatise on the products of combustion of fuels and their effects, written by H. B. Meller and L. B. Sisson of the Mellon Institute of Industrial Research, Pittsburgh, Pa. The text was prepared so that it may be used in the form presented or the subject matter may be divided and part of it included in a course in chemistry and part in a course in physics in any high school or preparatory school. Engineers interested in the problem of smoke elimination will find this short but comprehensive booklet helpful as it contains information and advice needed not only when faced with the necessity of choosing new equipment but also in the selection of fuel and the best method of burning it to secure efficient and practical smokelessness.

ROBINS CONVEYING BELT Co., 15 Park Row, New York City, is distributing a new bulletin, No. 96, describing the improved McCaslin pivoted bucket conveyor recently perfected by the Mead-Morrison Division of the Robins Conveying Belt Co.

CROUSE-HINDS Co., Syracuse, N. Y., has just issued their new general catalog of Condulets. This is a voluminous book consisting of 120 separate sections, arranged in loose leaf form and very thoroughly indexed. It contains complete information on all types of conduits and fittings.

BUREAU OF INDUSTRIAL STANDARDS of the Commonwealth of Pennsylvania, Department of Labor and Industry, Harrisburg, Pa., has recently issued a 28-pp. pamphlet on Asbestosis, giving an account of the nature and amount of dust encountered, the effect on health of workers of exposure to this dust in asbestos fabricating plants.

"ARTIFICIAL LIGHT AND ITS APPLICATIONS," a text book prepared for use in connection with the Employee Education Plan which the Westinghouse Lamp Company is sponsoring through its Better Light-Better Sight program for 1935-36, is ready for distribution to the lighting engineers of utilities and manufacturers.

Divided into thirteen chapters, the new text covers every phase of the lighting art, from fundamental theory to all classes of present-day practice. Several new sections cover the new vapor illuminants, namely, the sodium vapor and the high intensity mercury vapor lamps, which have only come into accepted use in the past few years. Their technical function is discussed in a chapter on light sources, and their application is described in the chapters on commercial, flood, and street lighting.

"Artificial Light and Its Applications" is bound in heavy green paper, trimmed in black, and its 258 pages are printed in typewriter type by the photo-litho process. Copies may be obtained at the printing cost of 50c by writing to the Commercial Engineering Department, Westinghouse Lamp Company, Bloomfield, New Jersey.

DE LAVAL STEAM TURBINE Co., Trenton, N. J., is distributing reprints of an article on worm gears dealing with the principles controlling design, ratios available, efficiencies to be expected, requirements as to lubrication and the standard formulas according to which such gears are now rated.

THE ELECTRIC CONTROLLER & Mfg. Co., Cleveland, Ohio, has issued two 4-page leaflets, Nos. 1140 and 1145, describing their new type LTZ Contactors for A. C. service and new Line Arc Contactors, respectively.

TUNE IN FOR LOWER PROCESS COSTS is the title of a bulletin issued by The Brown Instrument Co. of Philadelphia, Pa., illustrating and describing the features of the air operated controllers recently introduced by this company.

COMPLETE DESCRIPTIONS with engineering data and suggestions intended as a guide to the engineer in designing his own conveyors are included in Sectional Catalog No. 106 of the Palmer-Bee Co., Detroit, Mich. This catalog covers four types of conveyors: fan type, belt type, screw type and skip hoist type for the handling of bulk material for elevating and conveying installations. It is the sixth of 12 sections which make up this company's general catalog.

CONDENSED CATALOG of its equipment is covered in an 8-page bulletin recently issued by Ruggles-Klingemann Mfg. Co., 38 Chauncey St., Boston, Mass.

ANNOUNCEMENT is made by the Bristol Co., Waterbury, Conn., of its new wide strip pyrometer, using a 12¼ in. strip chart with 11 in. graduated scale. This new instrument is described in catalog No. 1450.

SIZES AND LIST PRICES of Worthington Multi-V-Drives with Goodyear Emerald cord belts are included in bulletin L-400-B7 issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

STORAGE TANK heaters for fuel oil, lubricating oil and various chemicals are covered in a new bulletin, Form 496, by the Griscom-Russell Co., New York, N. Y. The bulletin shows the construction of the heaters and their arrangement in the tanks to meet different plant needs.

SINGLE CYLINDER horizontal, single stage, motor driven compressors and horizontal duplex power pumps with totally enclosed frames and anti-friction bearings for the petroleum industry are covered in bulletins L-611B4A and W-412B5 of the Worthington Pump & Machinery Corp., Harrison, N. J.

PHEOLL MFG. Co., 5700 Roosevelt Road, Chicago, Ill., has just issued its 1936 edition of its catalog containing the latest price lists, American Standard dimensional data, weights, tables and other information on the subject of screws, bolts and nuts.

ALLIS-CHALMERS has released four new illustrated leaflets on Centrifugal Pumps as follows: Leaflet 2206 Large, low-head, double suction, single stage, Type S pumps. Leaflet 2207 Large, high-head, double suction, single stage, Type S pumps. Leaflet 2208 Small, double suction, single stage pumps. Leaflet 2210 Type M Multi-stage, double suction pumps.

SYMBOLS FOR METERING DIAGRAMS is a report of the Electrical Committee of the Edison Electric Institute. These standardized symbols have been prepared to simplify wiring diagrams, make comparisons of different methods easier and to facilitate checking of diagrams and connections. The publication is known as No. C10, sells for ten cents and may be obtained from the headquarters of the Institute at 420 Lexington Ave., New York, N. Y.

METHODS OF MEASURING RADIO NOISE is the title of Edison Electric Institute Publication No. C9 prepared in conjunction with the N.E.M.A. and R.M.A. The price is 35 cents to non-members and copies may be obtained from the society headquarters, 420 Lexington Ave., New York City.

YARNALL-WARING Co., Chestnut Hill, Philadelphia, has issued a new edition of their catalog, Yarway Expansion Joints. This publication is designated EJ-1905 and supersedes EJ-1904.

NATIONAL RADIATOR CORPORATION, Johnstown, Pa., has recently issued an attractive 12 page bulletin entitled "National-Williams (Oil-o-matic) Boiler Burner Units."

LUKENS NICKEL-CLAD equipment is described in a recently published 24 page bulletin issued by the Lukens Steel Co., Coatesville, Pa.

WORTHINGTON PUMP & MACHINERY Corporation has issued several new bulletins describing their products. Bulletin M-975-B30 is devoted to Worthington-Gamon, Watch Dog Water Meters. Bulletin 1101 and 1108 both issued by the Carbondale Machine Corporation, a unit of the Worthington Co., are devoted to Carbondale Refrigeration Compressors.

CONDOR ASBESTOS Friction Material for Industry is the subject of a new bulletin issued by the Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J. The bulletin describes the types of friction material which are manufactured by the company, illustrates and describes a number of industrial applications and gives tables of sizes and prices helpful to engineers in making selections.

JAMES G. BIDDLE Co., 1211 Arch St., Philadelphia, Pa., describes in its Bulletin No. 1435 the Jagabi speed measuring instruments which are used extensively in power plants, particularly for testing purposes. The Frahm vibrating-reed hand tachometers are also described and illustrated.

A SIXTEEN-PAGE catalog just issued by Combustion Engineering Company, N. Y., describes recent improvements in details in the Coxe stoker and its drive. All its parts are exceptionally well illustrated. A two-page blue print spread shows typical settings of this stoker as applied to different types of boilers and numerous installation photographs are included. Air control, drive and furnace arrangement are discussed at some length.

COMBUSTION Engineering Company, New York has just issued a 16-page catalog illustrating and describing details of its sectional-header type boiler as built for a wide range of steam pressures, capacities and different methods of fuel firing. In addition to the details of design, cross-sections of numerous representative installations are included.

Power Plant Construction News

Calif., Los Angeles—Grant & Bruner, Ltd., 307 South Hill Street, Los Angeles, consulting engineers, have plans under way for new cold storage and refrigerating plant in Northern California, for company whose name is temporarily withheld. Cost over $200,000, with equipment.

Calif., Los Angeles—Shell Oil Co., 315 Derby Street, San Francisco, plans power station unit for operation of new oil refining plant at Dominguez, Los Angeles. Pumping station and other mechanical units will be built. Entire project will cost close to $1,000,000. Company engineering department is in charge.

Calif., San Francisco—Pacific Steel Foundry Co., Eighteenth and Treat Streets, plans installation of power equipment, mechanical-handling apparatus, etc., in connection with proposed rebuilding of portion of plant, recently destroyed by fire. Loss reported close to $50,000.

Fla., Miami—Canada Dry Ginger Ale, Inc., 122 East Forty-second Street, New York, N. Y., plans installation of electric power equipment in proposed new plant at Miami, where site has been selected, to include complete mechanical bottling works. Cost over $60,000.

Ga., Columbus — Archer Hosiery Mills, Talbotton Avenue, plans new one-story boiler plant in connection with expansion at knitting mills. Entire project will cost about $40,000, and will be placed under way at early date.

Ill., Chicago—Sherwin-Williams Co., East 115th Street and South Cottage Grove Avenue, plans installation of electric power equipment in new addition to local paint and varnish factory. Project will be carried out in 1936. Entire expansion will cost close to $800,000. Main offices of company are at 101 Prospect Avenue, N. W., Cleveland, Ohio.

Ill., Rochelle — Rochelle Asparagus Co., plans installation of electric power equipment in new one-story addition to canning plant, 100x200 ft. Work will proceed at once. Cost over $55,000.

Ind., Hammond—Lever Brothers Co., 164 Broadway, Cambridge, Mass., plans installation of electric power equipment in new additions to soap manufacturing and edible oil works at Hammond, including complete new unit for production of a vegetable lard substitute. Cost over $4,000,000. Work will be carried out during 1936.

Ind., Lawrenceburg—Schenley Distillers Corporation, 20 West Fortieth Street, New York, N. Y., plans installation of electric power equipment in new addition to distillery at Lawrenceburg. designed to double present capacity. Cost about $700,000. Project will be carried out early in 1936. Carl J. Kiefer, Schmidt Building, Cincinnati, Ohio, is consulting engineer.

Iowa, Alta.—Common Council has authorized estimates of cost for extensions and improvements in municipal electric light and power plant, including installation of new equipment. Proposed to begin work early in 1936. Buell & Winter Engineering Co., Insurance Exchange Building, Sioux City, Iowa, is consulting engineer.

Iowa, Cedar Falls—City Council is considering construction of new municipal artificial gas plant. Cost about $65,000, with equipment. C. H. Sreeter is city engineer.

Kan., Hoisington—City Council has plans maturing for new municipal electric light and power plant, for which fund of $200,000 has been secured through Federal aid. Proposed to begin work soon. W. B. Rollins & Co., Railway Exchange Building, Kansas City, Mo., are consulting engineers.

Ky., Frankfort — National Distillers Products Corporation, 120 Broadway, New York, N. Y., plans installation of electric power equipment in connection with expansion and improvement in former plant of E. H. Taylor Distillery, Frankfort, recently acquired. Cost in excess of $300,000.

La., New Orleans—Johns-Manville Corporation, 22 East Fortieth Street, New York, N. Y., plans installation of electric power equipment in new one-story plant, 150x800 ft., in Jefferson Parish, vicinity of New Orleans, where site has been acquired, for manufacture of building material products, insulation board, etc. Entire project will cost about $600,000. Work will be carried out during 1936. S. A. Williams is vice-president in charge of factories.

Miss., Columbia—Dorgan-McPhillips Packing Co., plans installation of electric power equipment in connection with proposed new additions to food products canning plant. Present capacity will be doubled. Cost over $50,000. A. P. Dorgan is vice-president.

Mo., Shelbina—Common Council is asking bids until Jan. 6 for equipment for municipal electric light and power plant expansion, including heavy-duty Diesel engine unit and accessory equipment. W. B. Rollins & Co., Railway Exchange Building, Kansas City, Mo., is consulting engineer.

Neb., Sutton—Common Council plans early rebuilding of municipal electric light and power plant, recently partially destroyed by fire. Loss estimated close to $100,000, including equipment.

N. H., Hinsdale—Hinsdale Paper Mfg. Co., plans installation of electric power equipment in connection with proposed rebuilding of paper mill, recently destroyed by fire. Loss close to $200,000. McClintock & Craig, 458 Bridge Street, Springfield, Mass., are consulting engineers.

N. Y., New York—Board of Directors, New York State Merchant Marine Academy, 80 Centre Street, plans installation of electric power equipment in connection with new institution at abandoned army post at Fort Schuyler, Throgs Neck, Bronx, including new buildings and improvements in present structures, with engineering unit, machinery hall and other mechanical divisions. Fund of $1,752,000 has been secured through Federal aid for project.

N. Y., New York—Board of Education, 500 Park Avenue, New York, plans installation of two power shops in new multi-story industrial high school for girls in Bronx. Also will install electric power equipment for service in industrial art shops and other mechanical units. A large boiler plant will be installed for central heating service. Entire project will cost close to $1,000,000. William C. Martin, Flatbush Avenue Extension and Concord Street, Brooklyn, N. Y., is architect and superintendent of schools.

N. Y., New York—Department of Hospitals, Municipal Building, has approved plans for new two-story power plant at Welfare Island, for institution at that place. Cost about $125,000. A building permit has been issued. Starrett & Van Vleck, 267 Fifth Avenue, New York, are architects.

N. Y., Rochester—Rochester Gas & Electric Corporation, 89 East Avenue, has plans maturing for new steam-operated electric generating station, on which work will be carried out in 1936. It will cost in excess of $1,000,000. Line extensions will also be made for rural electrification, including power substation and service facilities.

N. C., High Point—High Point Furniture Co., plans installation of electric power equipment in connection with proposed rebuilding of portion of factory, recently destroyed by fire. Loss about $50,000.

N. C., Rocky Mount—Public Works Department plans extensions and improvements in municipal electric light and power plant, with installation of additional equipment. Bond issue of $230,000 has been authorized for project.

Ohio, Sugar Grove—Ohio Fuel Gas Co., Sugar Grove, plans early rebuilding of pumping plant, recently destroyed by fire. Loss about $25,000, with equipment.

Okla., El Reno—Canadian Mill & Elevator Co., El Reno, H. K. Schafer, president, plans installation of electric power equipment, conveyors, hoists and other mechanical equipment in new elevator and mill unit, for which bids are scheduled to be asked soon. It will replace a plant destroyed by fire a number of weeks ago. Cost over $150,000. Horner & Wyatt, Board of Trade Building, Kansas City, Mo., are consulting engineers.

Okla., Henryetta—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of power equipment in connection with extensions in sheet glass plant at Henryetta. Entire project will cost close to $200,000. Plans have been approved.

Ont., Copper Cliff — International Nickel Co., Ltd., 67 Wall Street, New York, N. Y., plans installation of new furnace units and other power equipment, new stack and auxiliary structures, mechanical blowers, etc., in connection with expansion and improvement program at refining plant at Copper Cliff. Project will be carried out in 1936 and will provide for large increased capacity. Entire development will cost close to $2,000,000. Robert C. Stanley is president.

Pa., Foxburg—Clarion River Power Co., Foxburg, has preliminary plans under way for two new hydroelectric generating plants on the Clarion River. Cost reported over $600,000. Extensions will be made in transmission lines. Application has been made to Federal Power Commission for permission and hearing is scheduled early in 1936.

Va., Pulaski—Dobson-Miller Corporation plans installation of electric power equipment in proposed new addition to knitting mill for increased output. Cost over $35,000. J. C. Dobson is president and treasurer.

Wis., Milwaukee — Joseph Schlitz Brewing Co., plans installation of electric power equipment in connection with expansion and improvements in brewing plant, work to be carried out during 1936. Entire project will cost close to $850,000.